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(54) Full-automated washing machine and full-automated washing and drying machine

(57) In a full-automated washing machine and a full-automated washing and drying machine, the cloth amount is detected at the time that the operation is started by charging the washing into a drum (27) serving as a container in advance of teeming water, the cloth amount is decided as to whether to be permissible for drying or not and a decision result is displayed in advance of teeming water, and the user is urged to select any one of washing, rinsing, dehydration and drying processes by means of operation/input means (73) in advance of teeming water, thereby permitting operations under various conditions (the kind of cloths, the manner of laying cloths and ambient circumstances). The operation is decided as to whether to extend to drying or not in terms of at least three steps of fuzziness to ensure selection of any one of washing and drying processes even under a variety of conditions of cloths. Similarly, if the decision determines that the cloth amount should be decreased, if possible, for the purpose of sufficient drying, either the operation (course) which ends in dehydration following washing or the operation (course) which extends to drying can be carried out by selectively triggering automatic setting means; and if the cloth amount goes beyond a value permissible for drying to a great extent, execution of the drying process is inhibited. In detecting the cloth amount, the drum (27) serving as the container is once started and subsequently the power supply (88) for the motor (35) is turned off to cause the drum to continue rotating by inertia and then stop, so that a value corresponding to an overrunning amount of the drum may be determined; and in addition, the motor adapted to drive rotation of the drum is supplied, upon starting, with power which gradually varies from a low level to a high level and when a rotational position detector (1) carried on the rotary shaft (33) of the drum detects start of the drum, a value corresponding to a level of power supplied at that time (minimum level of power necessary for starting the motor) is determined. Then, a decision criterion for cloth amount is determined on the basis of the two values. Supply of power may be controlled by controlling the angle of electric conduction (conduction angle) of AC power supplied to the motor.

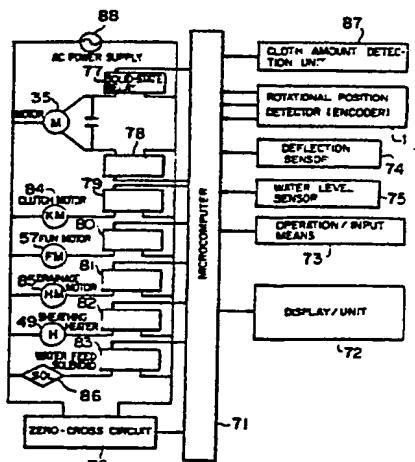


FIG.1

GB 2 247 250 A

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FIG. 1

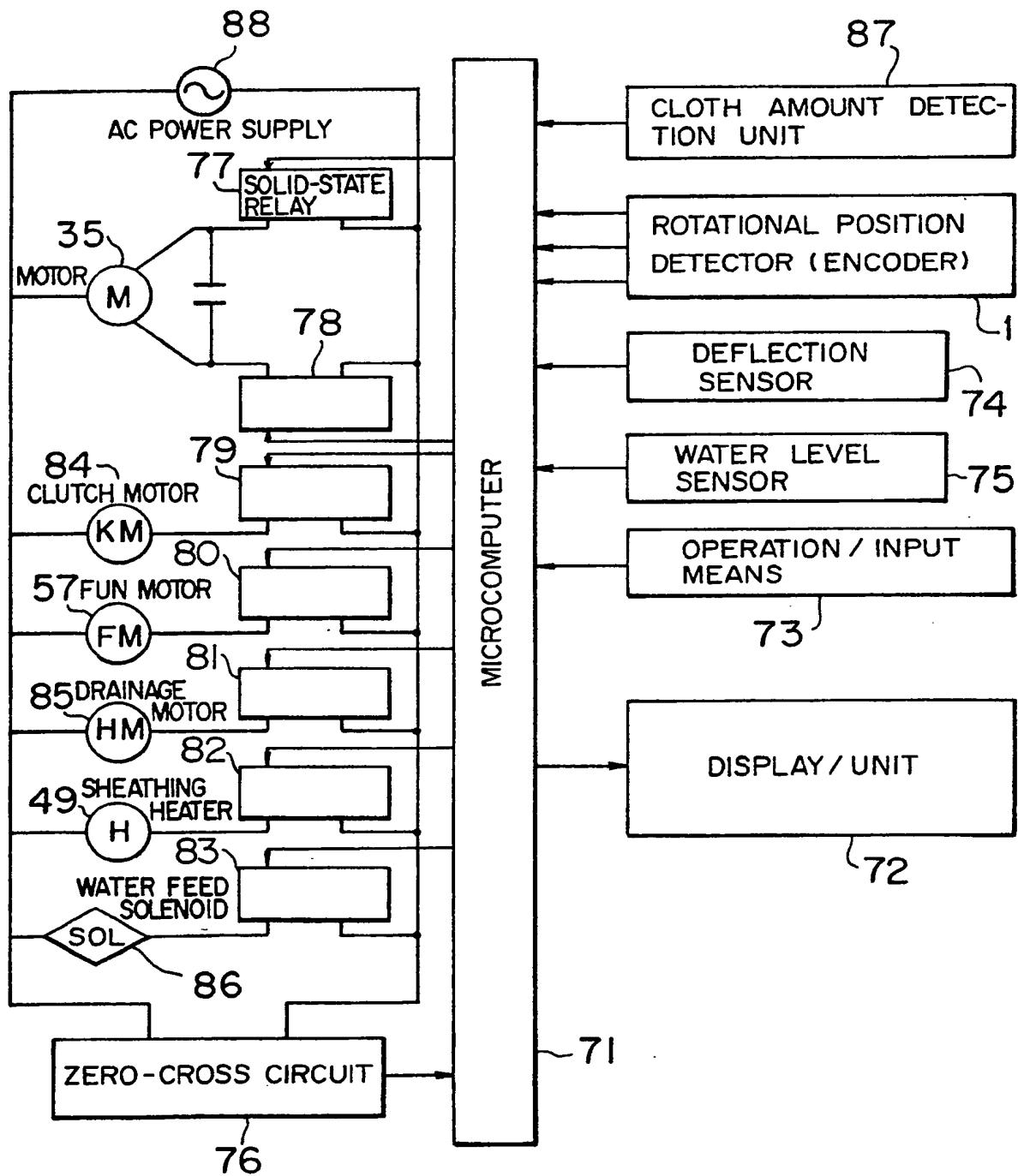


FIG. 2

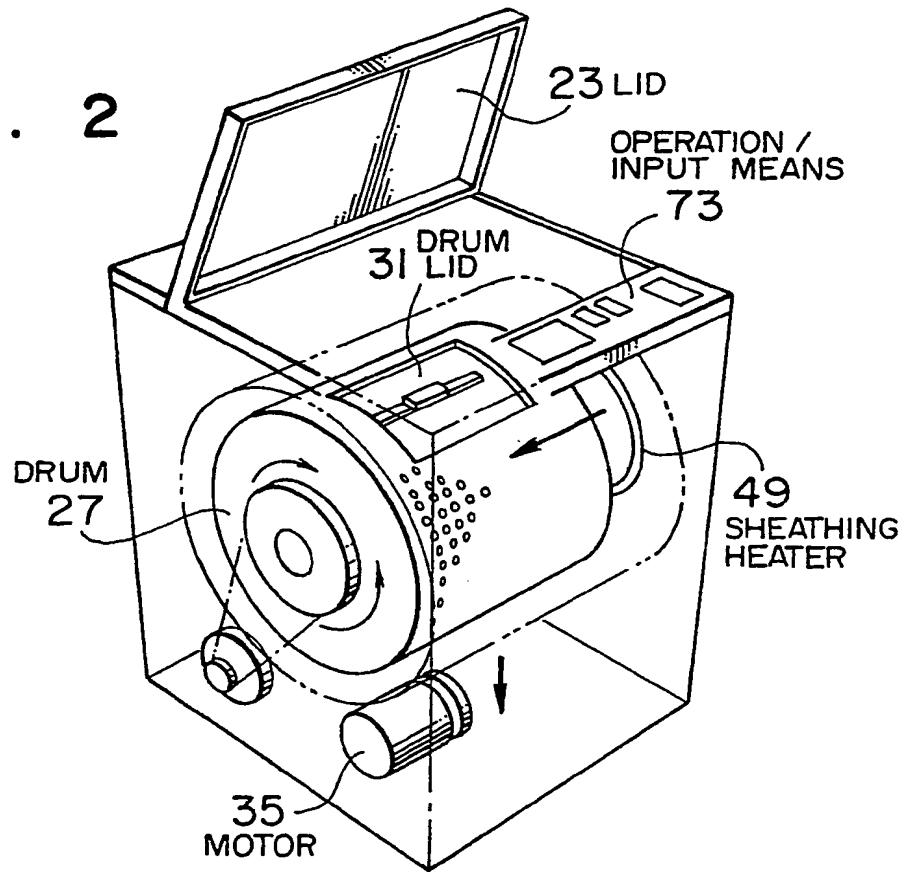


FIG. 3

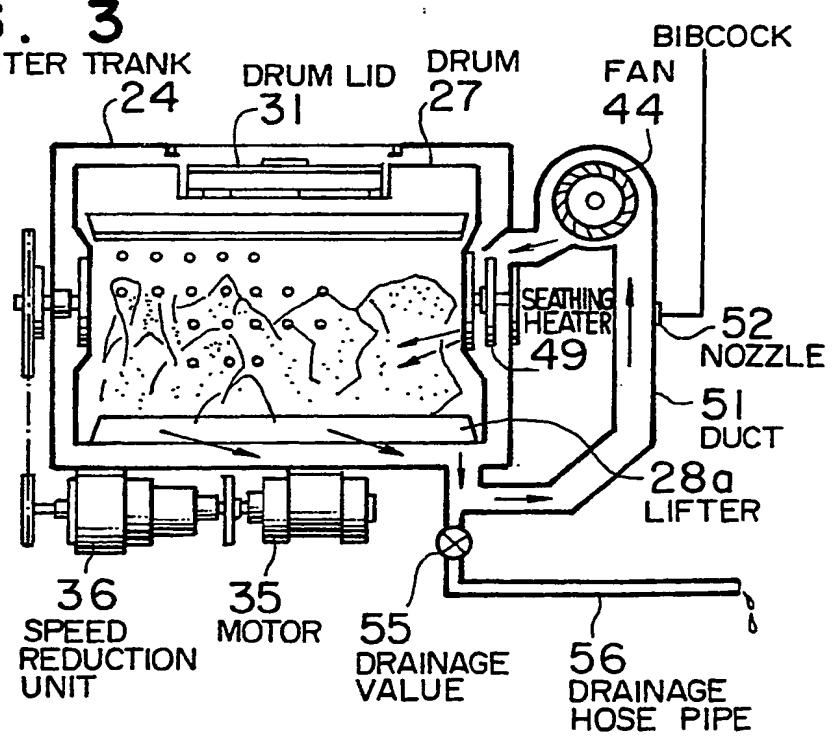


FIG. 4

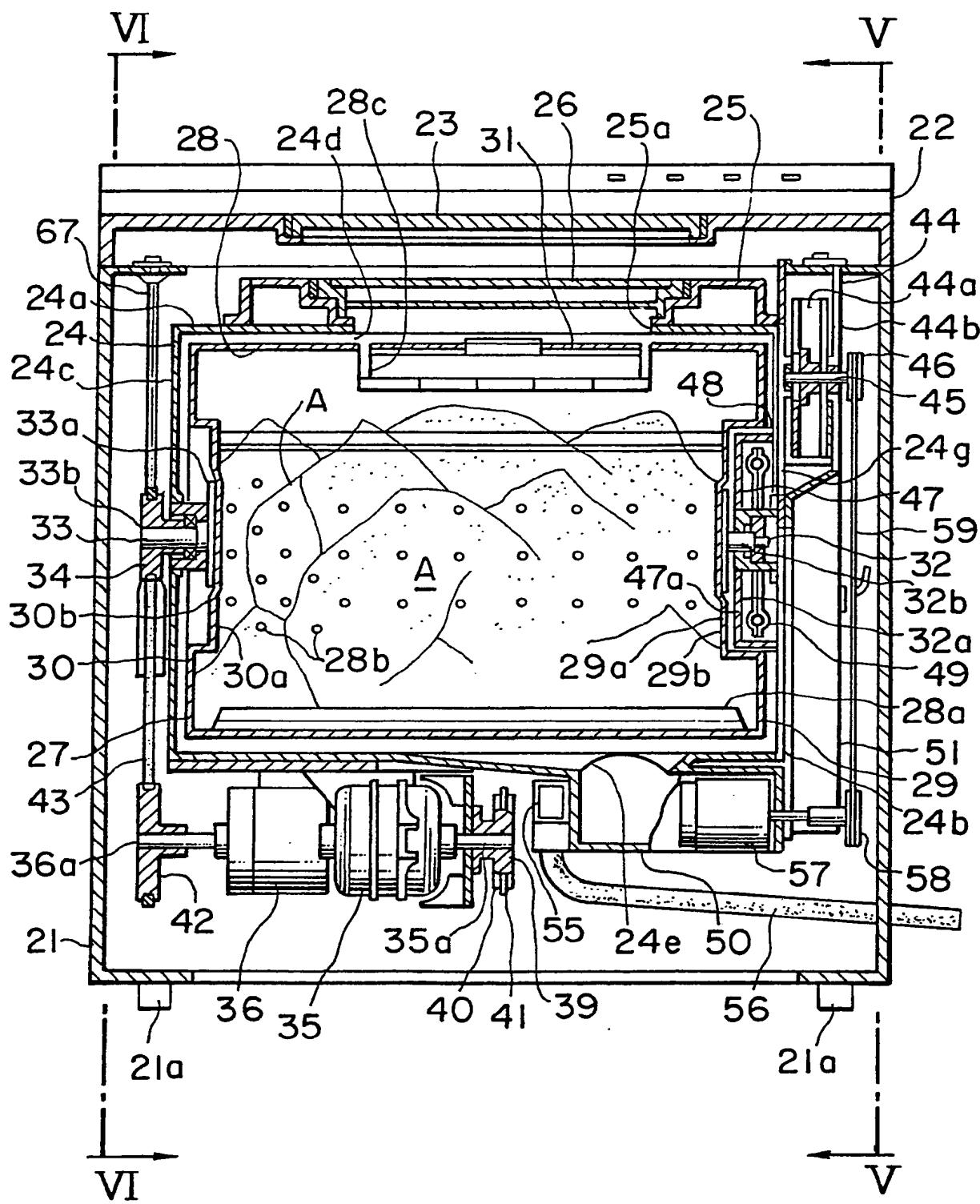


FIG. 5

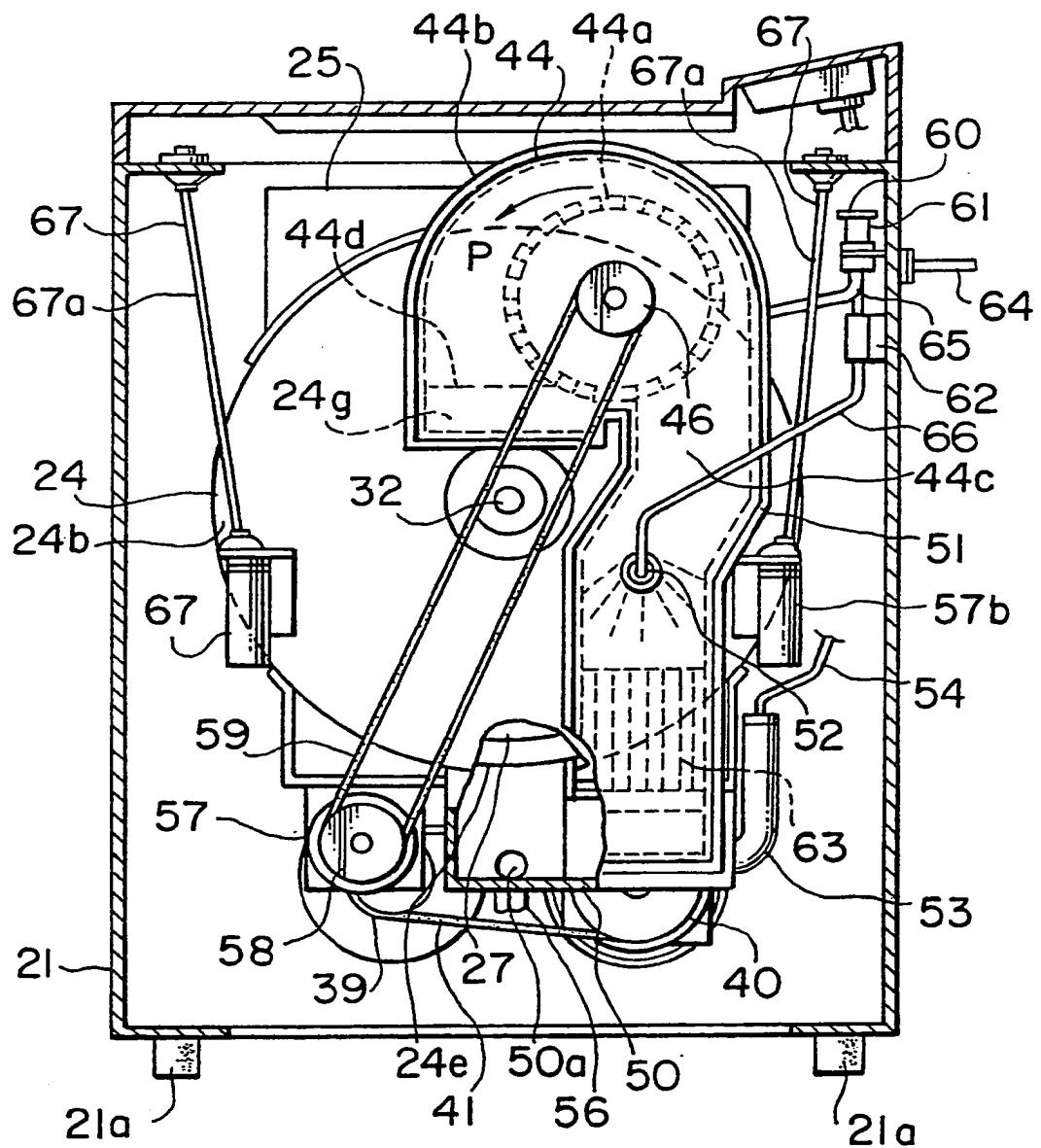


FIG. 6

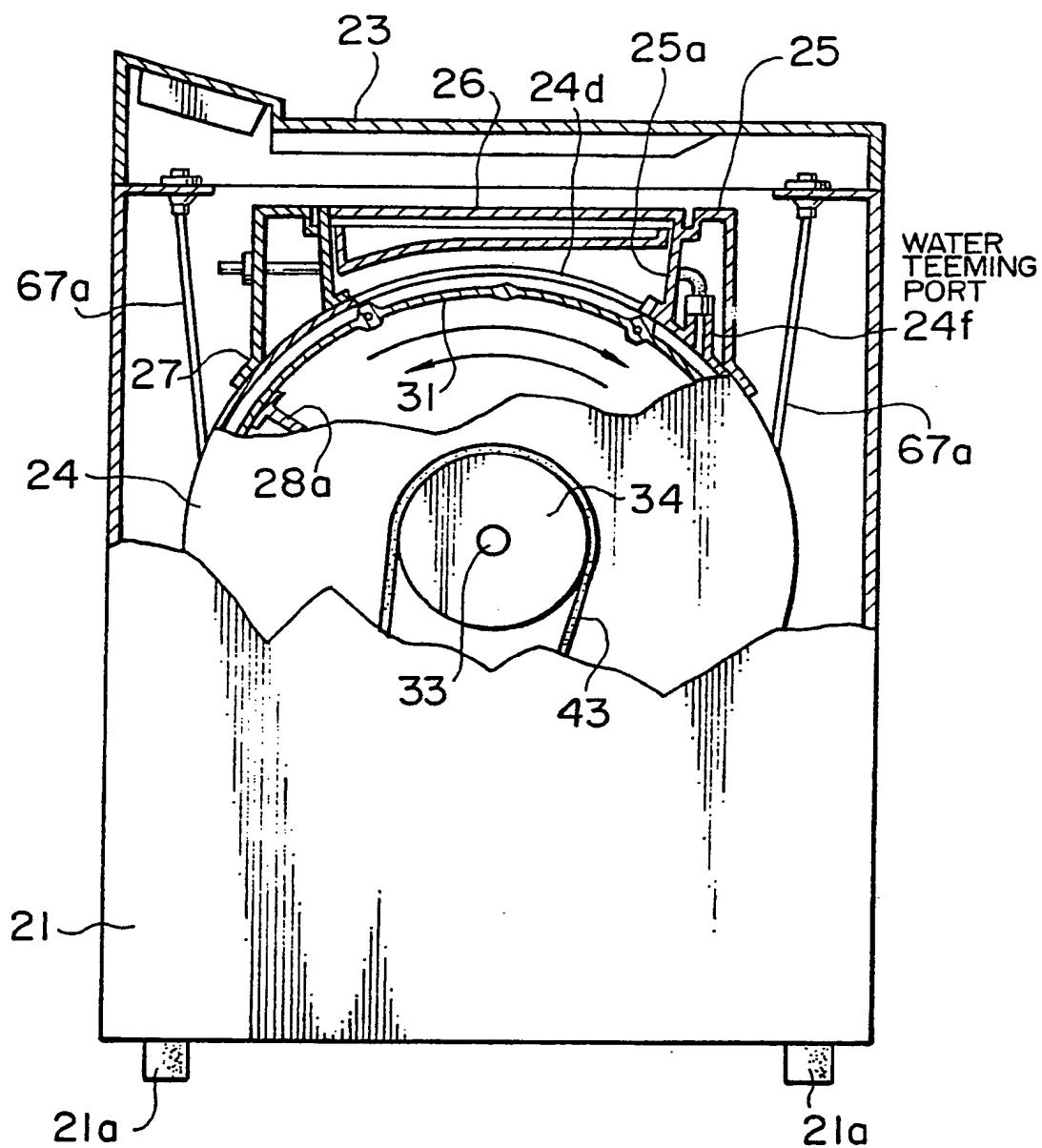


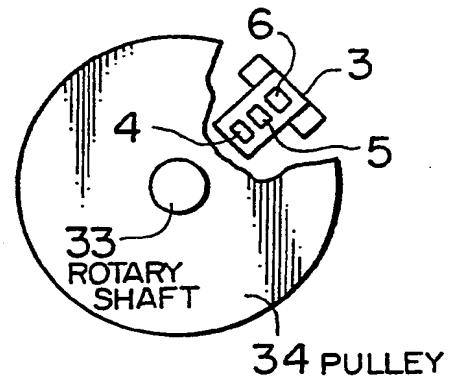
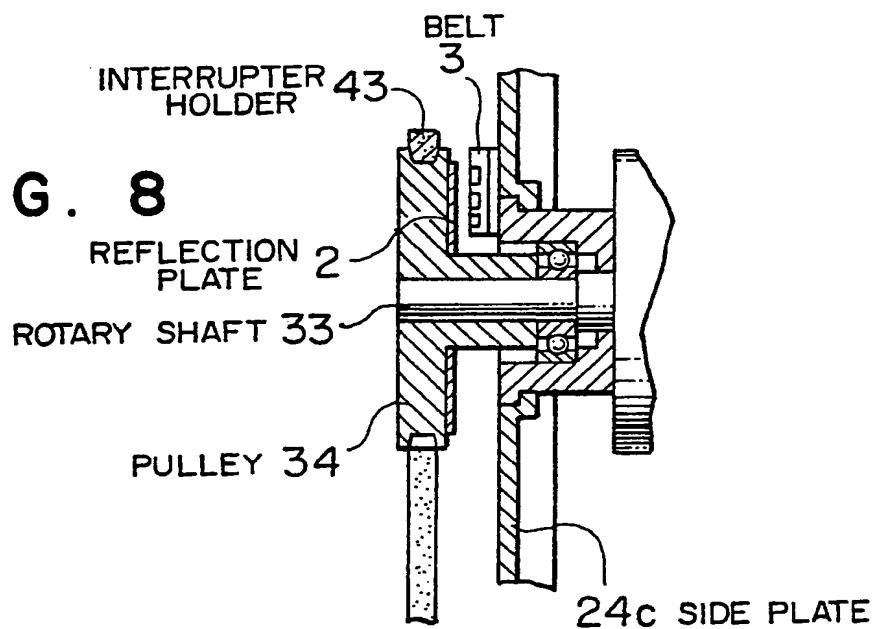
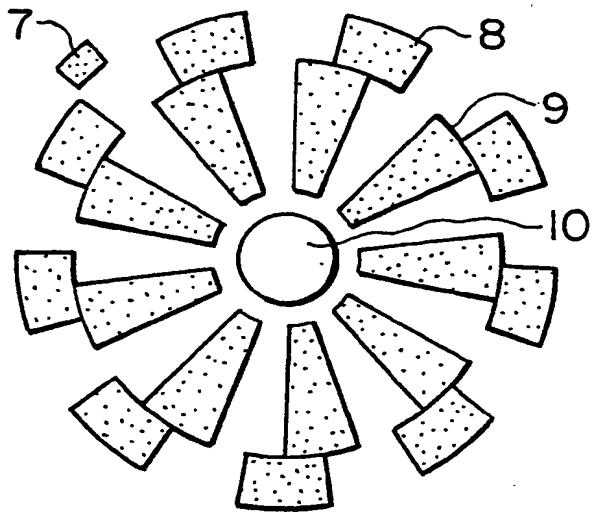
FIG. 7**FIG. 8****FIG. 9**

FIG. 10

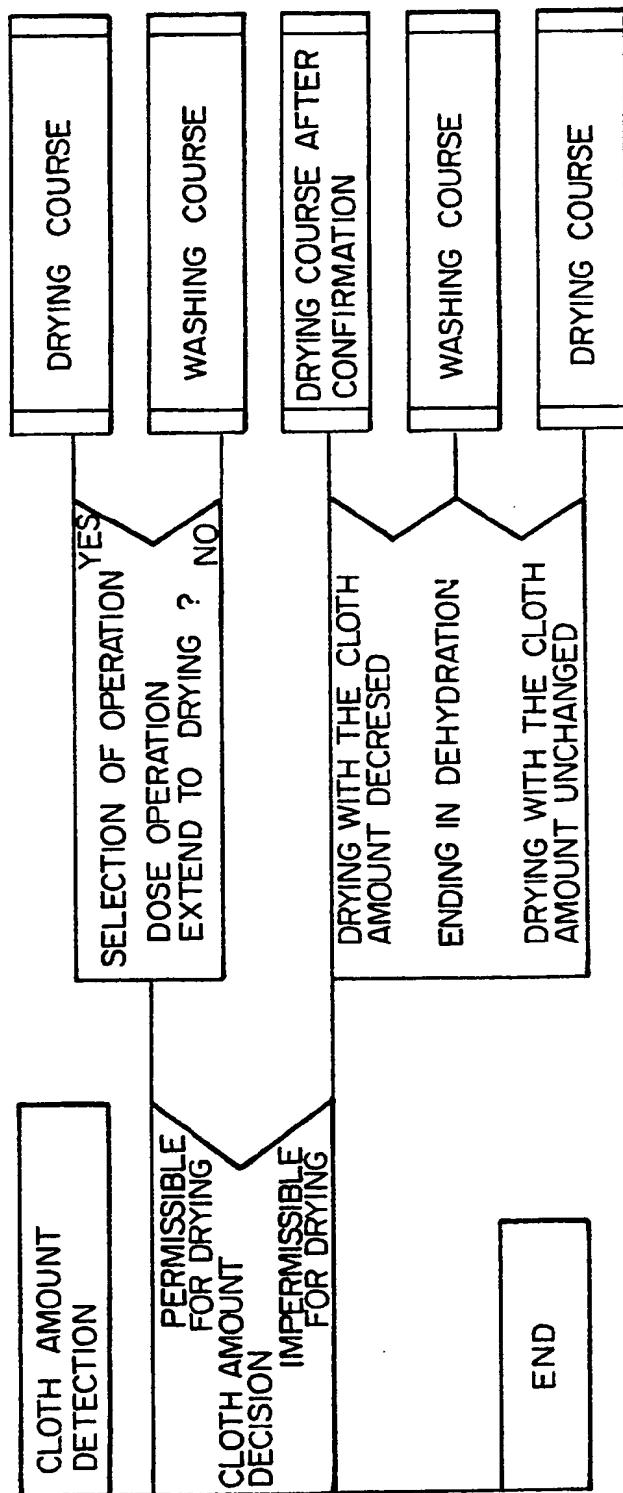


FIG. 11

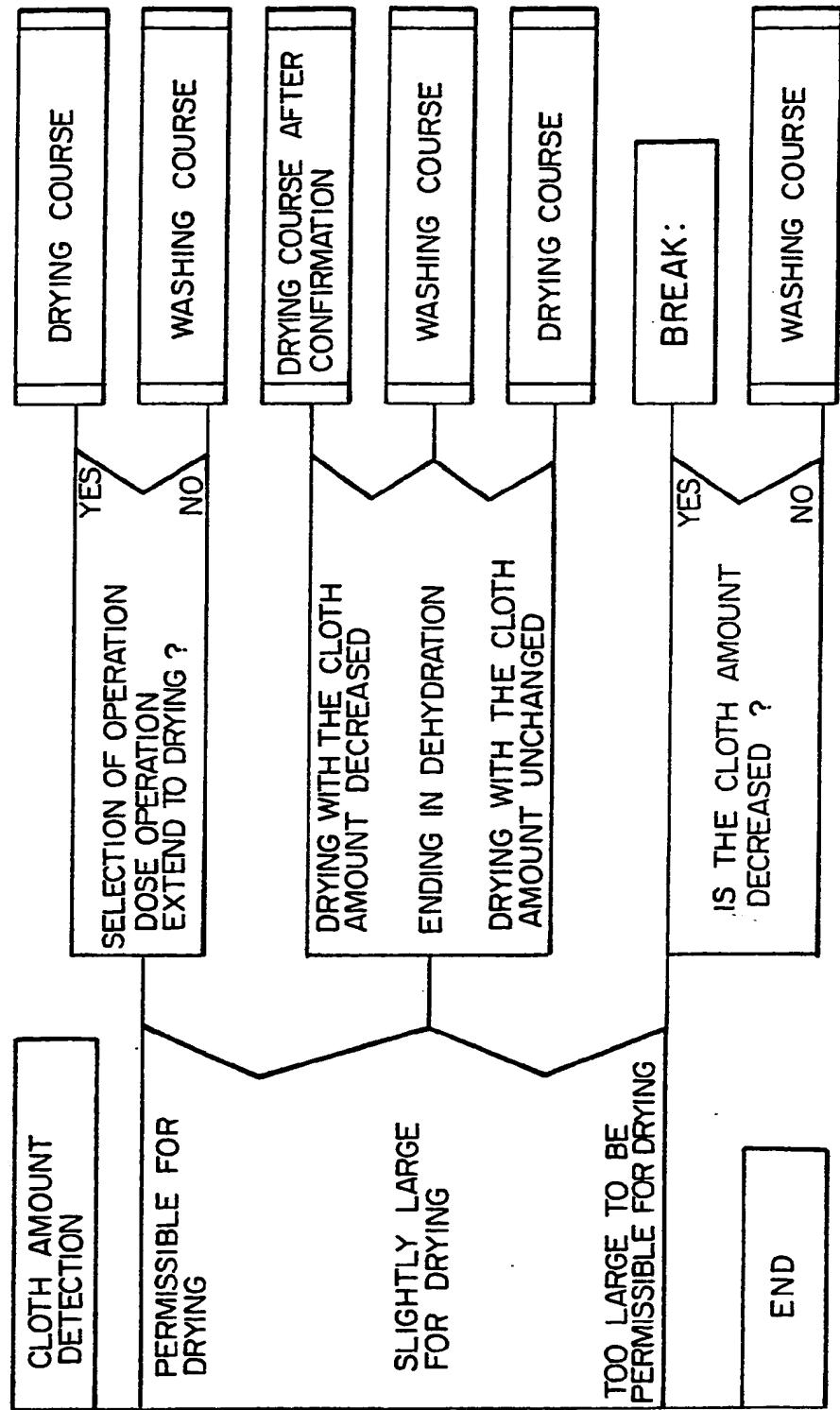


FIG. 12

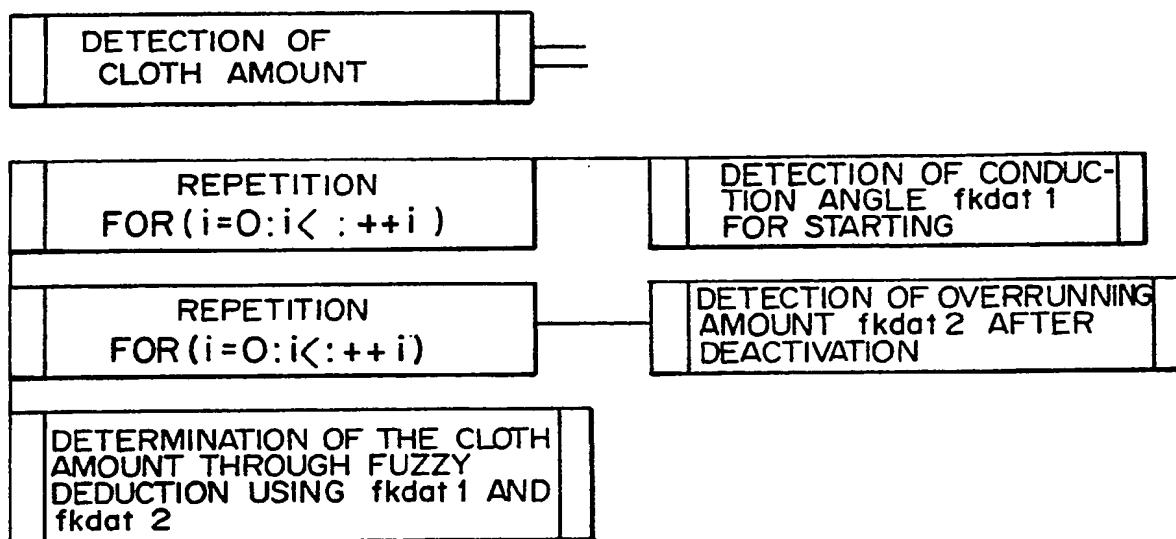


FIG. 13

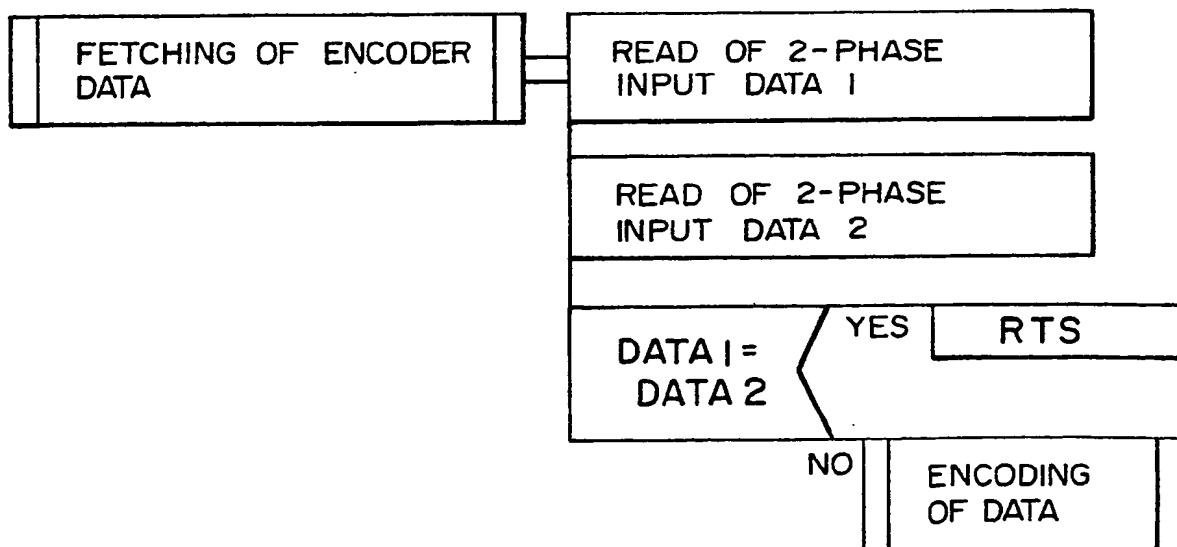
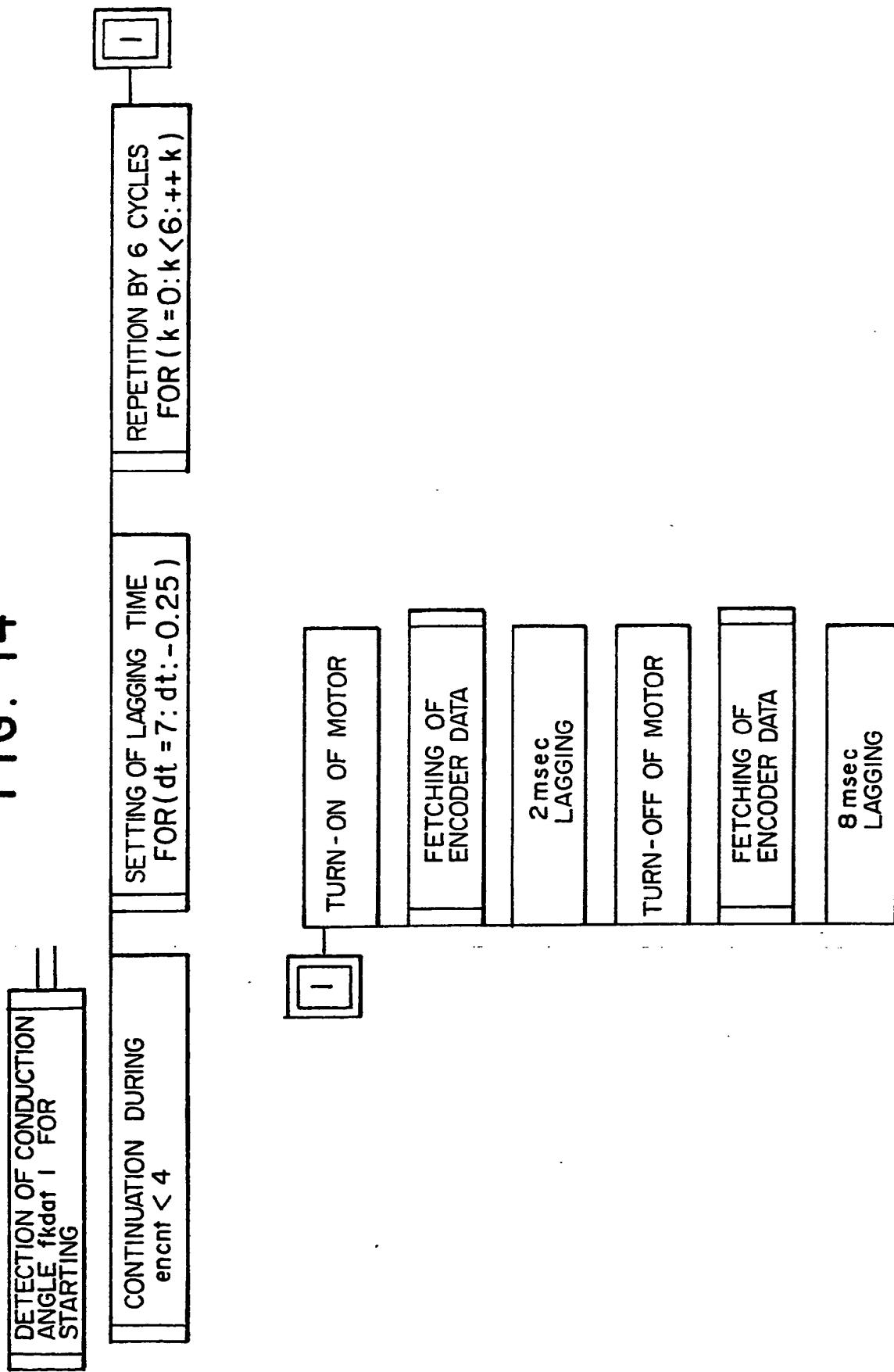


FIG. 14



11/1b

FIG. 15

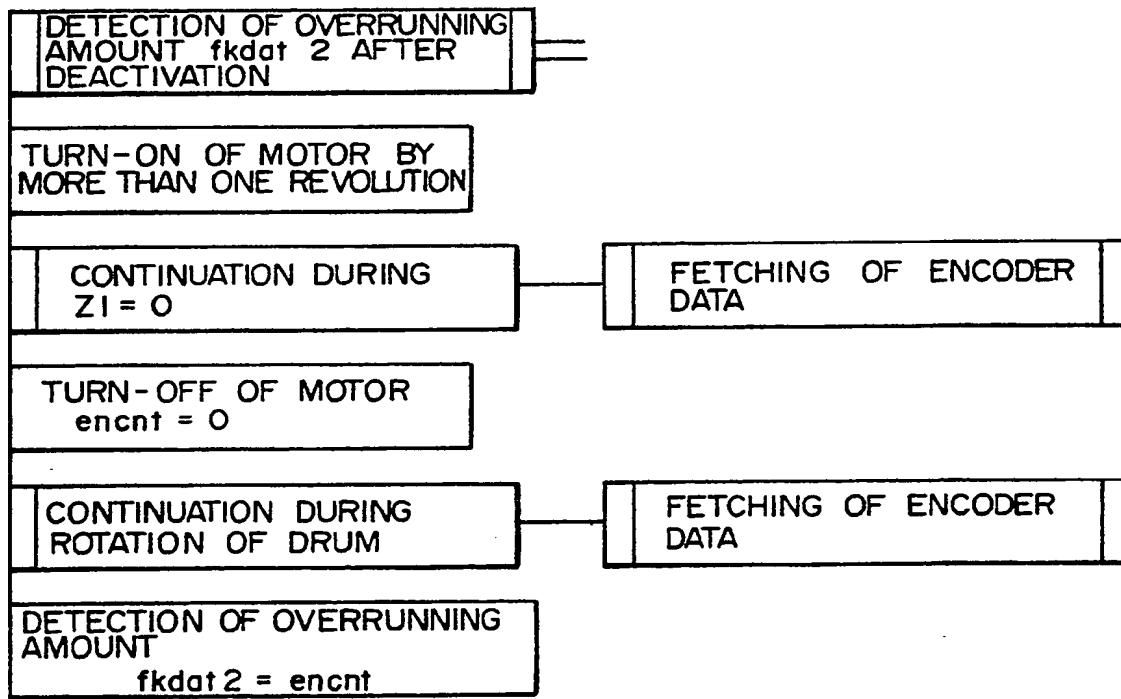
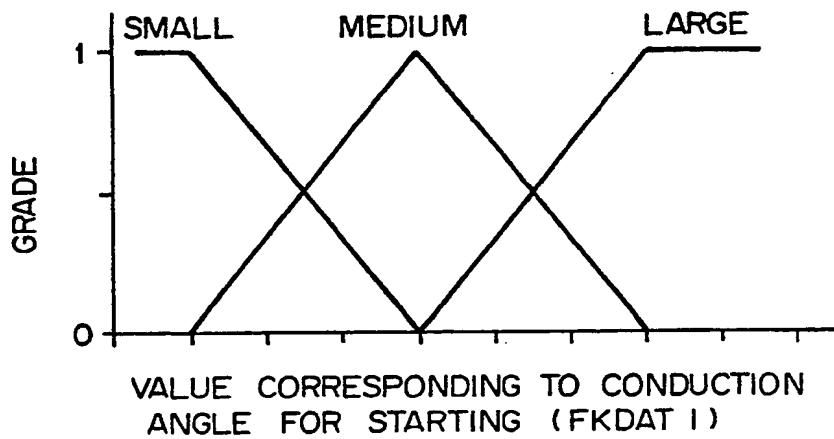
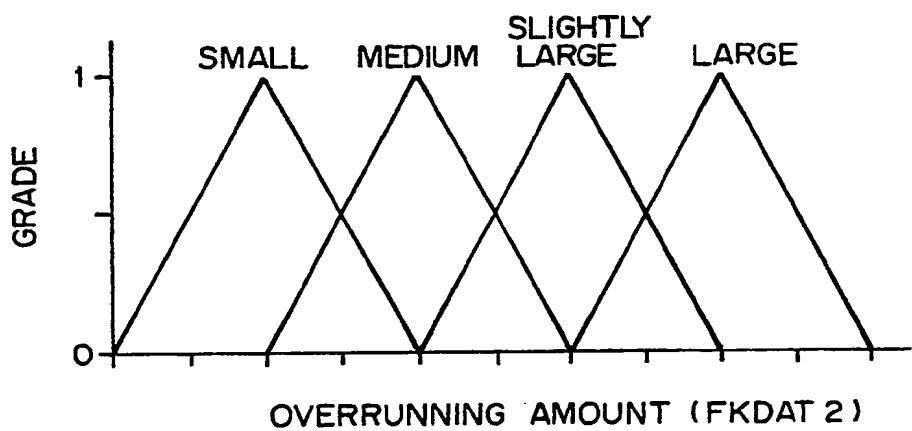
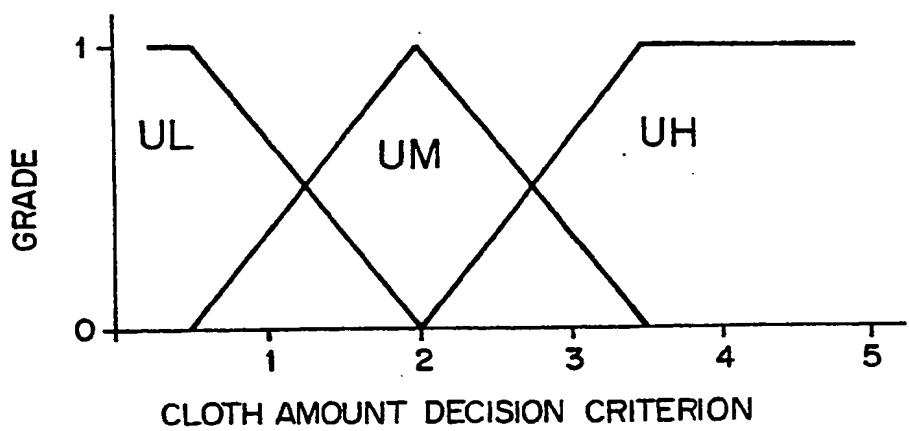


FIG. 16A**FIG. 16B****FIG. 16C**

13/16

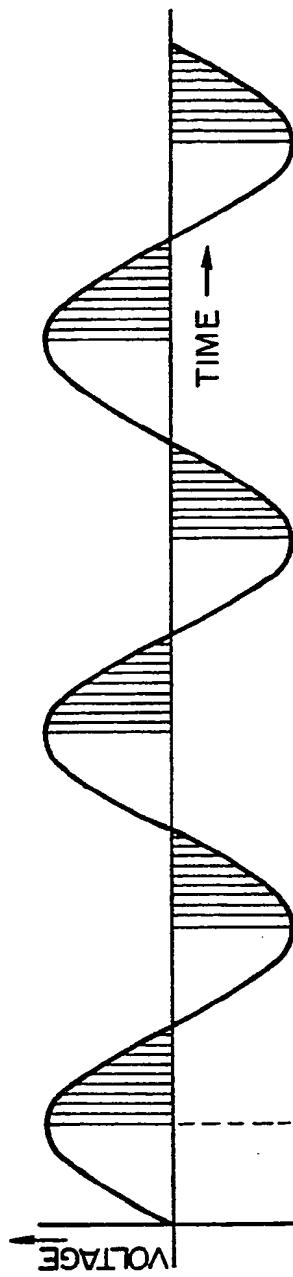


FIG. 17A

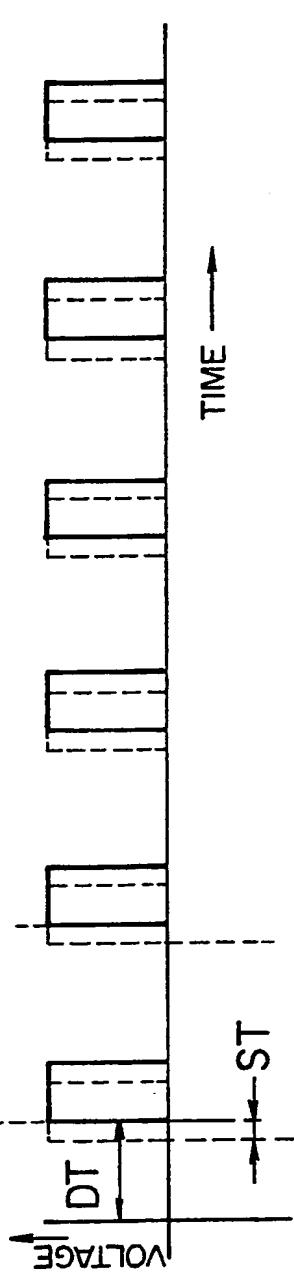


FIG. 17B

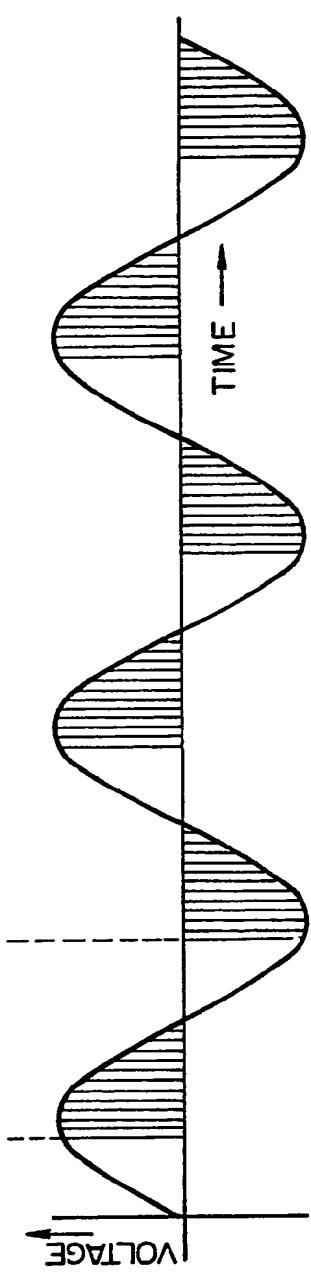


FIG. 17C

FIG. 18

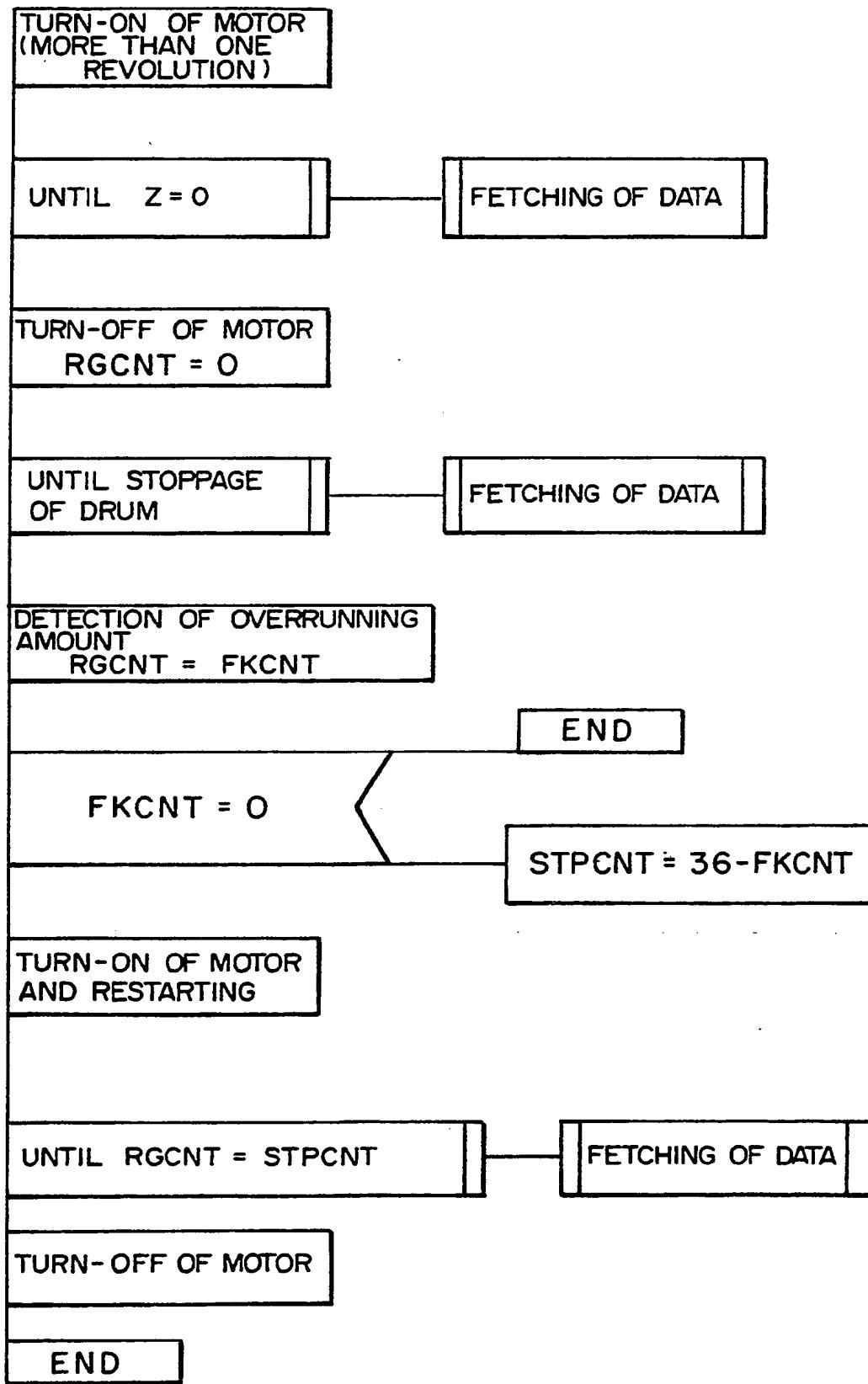


FIG. 19A

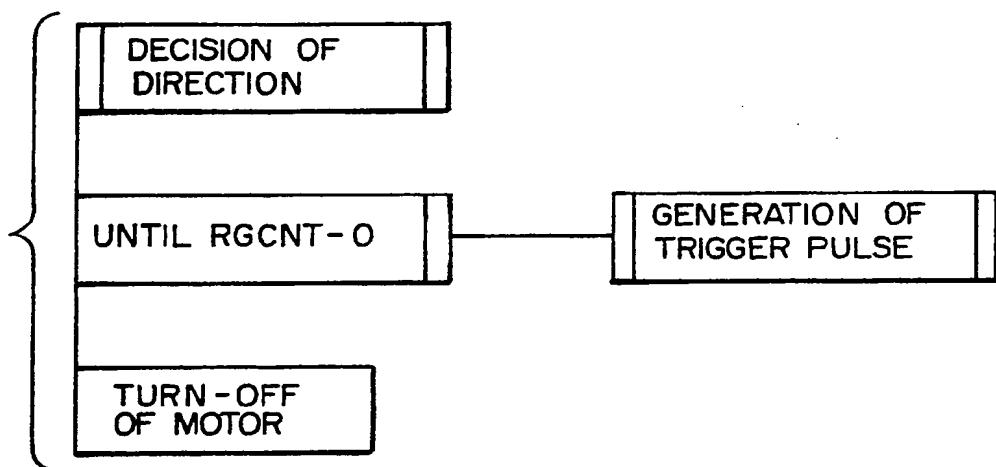


FIG. 19B

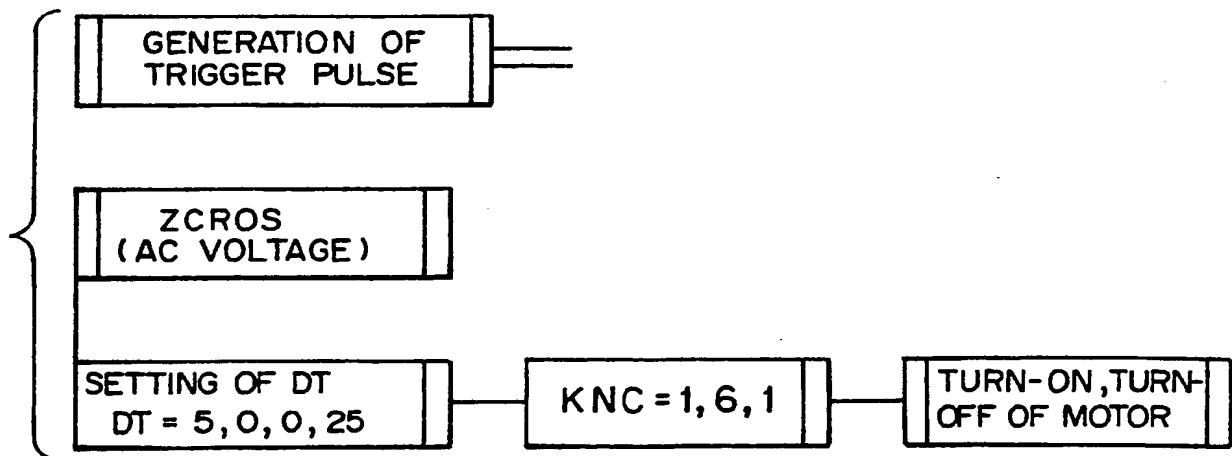
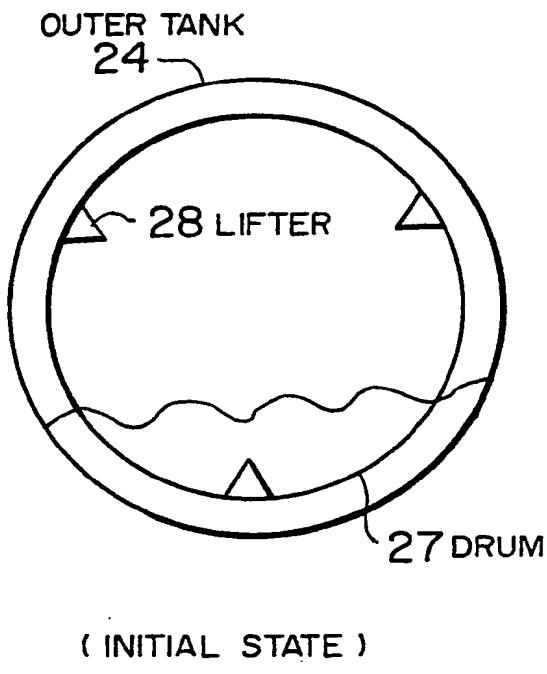
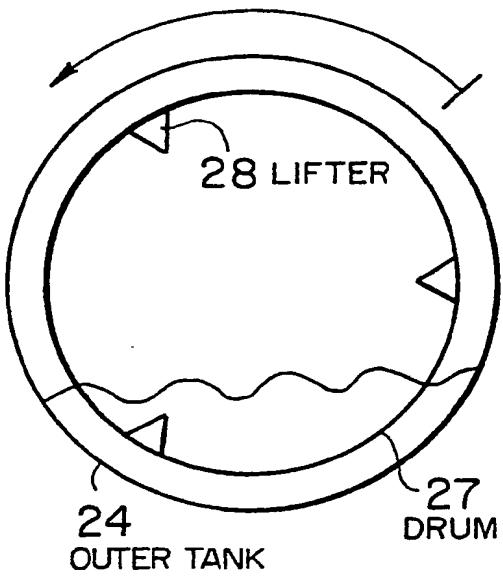
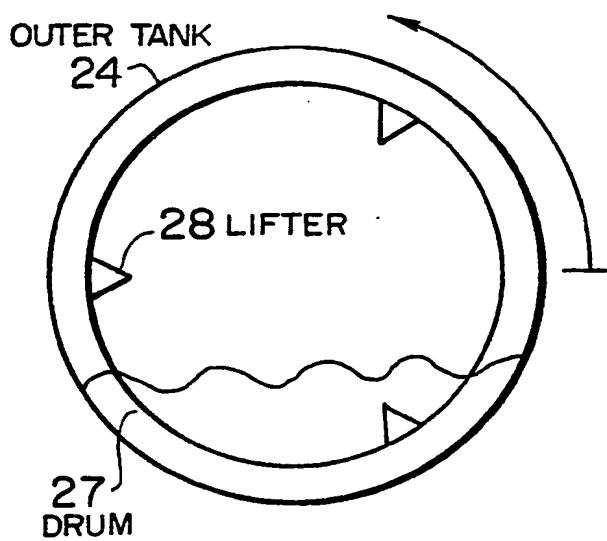


FIG. 20A

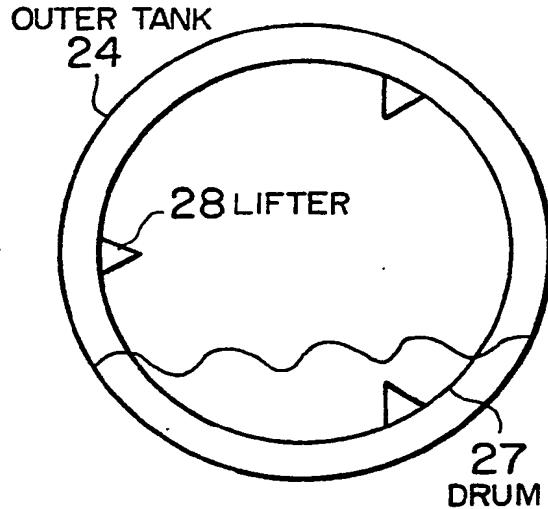
(INITIAL STATE)

FIG. 20B

1/4~1/2 REVOLUTION
(FOCIBLE ROTATION)
(DETECTION OF ROTATION ANGLE)

FIG. 20C

(INITIAL ROTATION)
(TURN-OFF OF MOTOR)

FIG. 20D

(INITIATION OF REVERSING)

FULL-AUTOMATED WASHING MACHINE
AND FULL-AUTOMATED WASHING AND DRYING MACHINE

The present invention relates to a full-automated washing and drying machine having a drum serving as a container into which cloths are charged and comprised of a cylinder formed with a great number of perforations, and a motor adapted to drive the drum for rotation, whereby water is teemed to cloths charged into the drum, the drum is driven for rotation by means of the motor to perform washing and thereafter dehydration and drying are carried out, to a full-automated washing machine in which the operation extends to dehydration and to a full-automated washing machine and a full-automated washing and drying machine which use a unit for stopping the drum at a home position.

The invention also pertains to washing and drying mechanisms suitable for improving washing and drying performance in the full-automated washing machine and full-automated washing and drying machine.

Conventionally, the following examples of the washing and drying machine provided with cloth amount detector have been available.

(1) In an example described in Japanese Patent Application Laid-open Hei 2-241493, the cloth amount is detected in accordance with the weight of cloths charged in advance of feed of water. If the detected

1 amount of cloths exceeds a predetermined value, admission
to the drying course is inhibited to inform the user
that selection of the drying course is not permitted.

(2) In a known example described in Japanese
5 Patent Application Laid-open Sho 62-243588, a value of
angular velocity upon start of dehydration and a value
of angular velocity upon stop of dehydration of the
dehydration tank containing cloths are measured using
centrifugal force, the relative magnitude of the cloth
10 amount is decided on the basis of two measured values,
and the rinsing time, water flow rate, dehydration
time and rotation number which are optimized for the
determined relative magnitude are set.

(3) In another known example described in Japanese
15 Patent Application Laid-open Sho 62-176491, the stirring
motor is rotated with a lower level of supplied power
when detecting the cloth amount than when washing, the
magnitude of the amount of cloths is detected on the
basis of the rotation number obtained in the course of
20 detection of the cloth amount, a proper water level
is automatically determined in accordance with the
detected cloth amount, and water feed is carried out.

(4) In another known example described in Japanese
Patent Application Laid-open Hei 2-49691, the amount of
25 the washing in the drum is decided on the basis of the
difference between an actual amount of water fed to the
rotary drum and a reference water feed amount.

(5) In a still another known example described

1 in Japanese Patent Application Laid-open Hei 1-274797,
fuzzy deduction is carried out on the basis of infor-
mation from sensors for detecting the state of the
washing so that the washing condition such as washing
5 time may be set.

Further, conventional techniques for stopping
the drum at the home position in the cloth drying
machine or the full-automated washing machine and full-
automated washing and drying machine are available
10 as follows:

(6) As described in Japanese Patent Application
Laid-open Sho 63-260594, there is provided a rotational
position detector for detecting the position of the
drum and when waiting time determined on the basis
15 of the period of rotation of the drum has elapsed
following arrival of the drum at a reference position,
electromagnetic braking is applied to the motor for
driving the drum to stop the same,

(7) As described in Japanese Patent Application
20 Laid-open Sho 63-260599, a rotational position detector
for the drum is provided and when the drum is not at a
predetermined position, it is so controlled as to be
once rotated in the reverse direction and thereafter
in the forward direction, and

25 (8) In the drum type washing machine, as described
in Japanese Patent Application Laid-open Sho 64-2690
and Japanese Patent Application Laid-open Sho 64-2691,
the rotation angle of the drum is detected by means of

1 a plurality of switches provided at predetermined
angular intervals.

In the conventional machine which automatically goes through washing and dehydration of drying,

5 (9) As described in Japanese Patent Application laid-open Hei 1-166799, the drum serving as the washing tank, dehydration tank and drying drum and formed with a great number of perforations is supported horizontally by means of bearings, and lifters extending radially
10 are formed on the inner peripheral surface of the drum, whereby when washing, the drum is filled with washing water up to an upper portion thereof and forward/reverse rotation of the drum is alternately repeated reiteratively at a short period. When drying, the drum
15 is operated in a similar way.

Disadvantageously, the prior art set forth so far do not fully take into consideration the following points: In example (1), either washing course or drying course is automatically set by simply deciding
20 in accordance with the weight of cloths whether drying is permissible or not. Therefore, even when, for example, the washing is allowed to be slightly wrinkled in consideration of a variety of conditions, for example, quality of cloths, the drying course cannot
25 be selected. Accordingly, the user cannot at all determine, at will, the operation which extends to drying. Further, this prior art in no way discusses display of the results of decision of cloth amounts in

1 advance of teeming water and operation/input means for
selecting the next operation in advance of teeming
water, so that decision by the cloth amount detector
cannot be used as auxiliary information which is utilized
5 by the user who decides as to whether the operation
should end in dehydration following washing or whether
the operation should extend to drying.

In example (2), due to the fact that the angular ac-
celeration represents a change in rotation number with
10 time, a variation in rotation number due to a variation
in the cloth amount is small as described on page 2
of Japanese Patent Application Laid-open Sho 62-176491
and therefore this prior art is unsuitable for detection
of cloth amounts with high accuracies.

15 In example (3) of rotation number detection type, even
if the stirring motor is operated with a low power
level, the influence of frictional loss in mechanism
components cannot be avoided and highly accurate cloth
amount detection cannot be expected.

20 In the full-automated washing and drying
machine which extends to drying operation, the amount
of the washing permissible for good drying finish
removed of wrinkle is in general smaller than the amount
of the washing subject to only washing without undergoing
25 drying. Therefore, when the washing is charged into
the washing tank to start washing, it is important
to decide whether the amount of the washing charged
is permissible for obtaining the satisfactory finish

- 1 state even when the operation extends to drying or the amount of the washing charged is permissible only for washing but is not expected to permit the satisfactory finish state.
- 5 In (4) example, even when it is known that the amount of cloths wetted by water feed is impermissible for drying, the cloth amount cannot be detected without feeding water, and the cloth amount is difficult to decrease, thus impairing ease of operation of the full-
10 automated washing and drying machine.
- 15 In (5) example, only the washing condition is set and decision as to whether the cloth amount is permissible for drying or not cannot be carried out. The cloth amount is merely one of input values for fuzzy deduction.
- 20 This prior art fails to take into consideration the ease of operation and the accuracy of cloth amount detection.

In addition, the aforementioned techniques for home position stoppage have the following disadvantages.

- 25 In (6) example, the halt position of the drum varies greatly not only with the off timing for the drum drive motor and the magnitude of load prevailing after the application of electromagnetic braking but also with, as described in Japanese Patent Application Laid-open Sho 62-243588, the frictional loss. Especially, in the drum type washing machine, the rotation angle of the drum greatly varies with the load as described

1 in Japanese Patent Application Laid-open Sho 62-2691.

In example (7), when the drum is not at the predetermined position, it is once rotated in the reverse direction and thereafter in the forward direction. In this 5 operation, however, the time lapse preceding the home-position stoppage is unstable as described on page 3 of Japanese Patent Application laid-open Sho 63-260594; especially, when a four-pole capacitor induction motor which rotates at a single speed is used to 10 drive the drum, oscillation will be liable to occur without the provision of a dead zone due to frictional loss.

In example (8) of drum type washing machine, the detection of the drum rotation angle by means of a plurality of 15 switches tends to suffer from a problem that distinction between forward rotation and reverse rotation is difficult to achieve. In the full-automated washing and drying machine, rotational positions and stop position of the drum can be detected with the same 20 rotational position detector more inexpensively than with a plurality of rotational position detectors.

In example (9) of prior art directed to improvement of washing and drying performance, when the cloth amount is small, the machine can operate satisfactorily but 25 as the load on the motor becomes excessive, the rotation angle per period is decreased and necessary washing power cannot be obtained. Further, the forward and reverse rotation angles are the same and symmetrical

1 with each other, raising a disadvantage that the washing
is always rubbed at the same portion and there results
great washing non-uniformity. Similarly, drying non-
uniformity tends to occur when drying.

5

An object of the present invention is to
provide a full-automated washing machine and a full-
automated washing and drying machine which can solve
the prior art problems to ensure ease of operation by
10 promoting convenience of a man-machine interface system
and to improve detection accuracy by avoiding the
influence of frictional loss in mechanism components
and which has a cloth amount detector capable of detect-
ing the amount of cloths in their dry state without
15 wetting them and uses a drum home position stopping
unit capable of solving problems encountered in the
conventional drum home position stopping technique,
whereby the prior art problems raised in connection with
the washing and drying performance can be eliminated
20 to improve the washing and drying performance.

To accomplish the above object, according to
the invention, the cloth amount is detected at the time
that the operation is started by charging the washing
into a drum serving as a container in advance of teeming
25 water, the cloth amount is decided as to whether to be
permissible for drying or not and a decision result is
displayed in advance of teeming water, and the user is

1 urged to select any one of washing, rinsing, dehydration
and dry processes by means of operation/input means in
advance of teeming water, thereby permitting operations
under various conditions (the kind of cloths, the manner
5 of laying cloths and ambient circumstances).

Further, the operation is decided as to
whether to extend to drying or not in terms of at least
three steps inclusive of fuzziness to ensure selection
of any one of washing and drying processes even under
10 a variety of conditions of cloths. Similarly, if the
decision determines that the cloth amount should be
decreased, if possible, for the purpose of sufficient
drying, either the operation (course) which ends in
dehydration following washing or the operation (course)
15 which extends to drying can be carried out by selectively
triggering automatic setting means; and if the cloth
amount goes beyond a value permissible for drying to a
great extent, execution of the drying process is
inhibited.

20 In detecting the cloth amount, the drum serving
as the container is once started and subsequently the
power supply for the motor is turned off to cause the
drum to continue rotating by inertia and then stop, so
that a value corresponding to an overrunning amount of
25 the drum may be determined; and in addition, the motor
adapted to drive rotation of the drum is supplied, upon
starting, with power which gradually varies from a
low level to a high level and when a rotational position

1 detector carried on the rotary shaft of the drum detects
start of the drum, a value corresponding to a level of
power supplied at that time (a minimum level of power
necessary for starting the motor) is determined. Then,
5 a decision criterion for cloth amount is determined
on the basis of the two values. Supply of power may
be controlled by controlling the angle of electric
conduction (conduction angle) of AC power supplied to
the motor.

10 The decision criterion for the magnitude of
cloth amount in the container may be determined by a
plurality of selected values which are substantially
proportional to at least the cloth amount. For example,
one value is proportional to the weight of cloths and
15 determined by detecting strain in shock absorbers for
buffer supporting the weight of the container, by means
of a strain gauge. The other value is proportional to
the moment of inertia of cloths and determined by
detecting by means of the rotational position detector
20 an overrunning amount generated when the drum is rotated,
deactivated once and overrun in the direction of rota-
tion after the deactivation. Then, fuzzy deduction is
carried out using the thus defined two values in the
conditional part to provide a decision criterion for
25 cloth amount. Other values than the above may be used
suitably in combination in the conditional part, including
a value representative of electromotive force due to
pressure detected by a piezoelectric sensor as in the

1 case of detection of the weight, a value representative
of the height of the cloths in the container and detected
by means of an ultrasonic sensor, and a value represented
of a quantity corresponding to a minimum level of power
5 necessary for starting the container (drum).

Especially, by using in the conditional part
a first value which is substantially proportional to
the moment of inertia of cloths and frictional loss
in mechanism components and a second value which is
10 substantially proportional to the moment of inertia
and is in inverse proportion to the frictional loss so
that the influence of the moment of inertia and that
of the frictional loss are cancelled out, fuzzy deduc-
tion is carried out to provide a decision criterion
15 for cloth amount.

Further, in order to attain the purpose asso-
ciated with the home position stopping technique,
when the drum is rotated and once deactivated, an over-
running amount, in the rotation direction of the drum,
20 due to inertial force by the load prevailing at that
time and frictional loss in the shaft are detected by
means of the rotational position detector. Then, when
the drum is restarted for rotation, a halt signal is
subsequently applied to the drum drive motor at a timing
25 which is modified by a reference position detectable
by the rotational position detector and corresponding to
the position of the lid.

By this, repetitive correction of the difference

1 between stop position and reference position can be
disposed with which is effected by driving the motor
in the forward and reverse directions alternately on the
basis of signals from the rotational position detector.
5 But, in order to improve accuracy of stop position of
the drum, a so-called soft starting process (described
in, for example, "Power Control Circuit Design Know-how"
by Arita and other two, CQ Shuppan Sha, pages 54 and 127,
1985) is employed wherein the direction of drive is
10 decided on the basis of the difference from the refer-
ence position, the drive motor is started by bringing
it to on-state from off-state in relation to the AC
power supply at a conduction angle of about 30 degrees
corresponding to a low power level and thereafter the
15 conduction angle is gradually increased.

The rotational position detector may be
realized with an incremental type or absolute type
encoder to accurately pick up forward and reverse rota-
tions of the drum, thereby controlling the rotation
20 angle of the drum during washing and drying or low speed
dehydration.

In order to attain the purpose associated with
improvement of the washing and drying performance,
according to the invention, the rotational position
25 detector for the drum is provided, the drum is rotated
in forward and reverse directions alternately at a short
period or cycle while detecting the rotation angle of
the drum, wherein the sum of an interval of time for

1 driving (forcible rotation) while detecting the rotation
angle of the drum and an interval of time for deactivated
rotation (inertial rotation) which ends at the inversion
of rotation is made to be asymmetrical by assuming dif-
5 ferent values in the forward and reverse directions.

According to the invention, the amount of
cloths in dry condition is detected, in advance of
teeming water, at the time that the washing is charged
into the drum, and either an indication purporting that
10 the cloth amount is small enough to permit the operation
to extend to drying following washing and dehydration
or an indication purporting that the cloth amount is
permissible for washing and dehydration but is too
large to permit the operation to extend to sufficient
15 drying is displayed to inform the user of the indication.
Then, the user is allowed to decide as to whether the
operation should extend to drying or whether the opera-
tion should end in dehydration through washing and
rinsing, so as to select the mode of operation, thus
20 preventing inconvenience that, for example, even when
the selected operation extends to drying with the
cloth amount decreased, cloths decreased in amount will
suffer from wet finish or inconvenience that even when
the operation expected to extend to drying is started,
25 the operation is forced to automatically end in dehy-
dration.

Further, the decision as to whether the cloth
amount is permissible for drying or not is displayed in

1 terms of three steps and therefore the freedom of
selection of the washing and drying courses predominates
to allow the user to determine one of various operations
at will, thus making a contribution to improvement of
5 ease of operation. Accordingly, the will of the user
is involved in automatic setting for the thus selected
course and a highly convenient man-machine interface
system can be realized.

According to the invention, in the cloth
10 amount detection, it is possible to detect whether a
change in the rotation overrunning amount of the drum
after turn-off of the motor power supply is due to a
change in the moment of inertia of the drum and cloths
(a change in the cloth amount) or due to a change in
15 frictional loss in mechanism components of the motor
adapted to drive the drum. More specifically, the
value corresponding to power supplied for starting the
motor adapted to drive the drum (minimum power necessary
for starting) increases in proportion to the magnitude
20 of moment of inertia of the drum and cloths and the
magnitude of the frictional loss, and the overrunning
amount of the drum after turn-off of the motor power
supply increases in proportion to the magnitude of moment
of inertia of the drum and in inverse proportion of the
25 magnitude of the frictional loss. As is clear from the
above, since the moment of inertia equally affects the
value corresponding to power supplied for starting and
the value corresponding to the overrunning amount of

1 the drum after turn-off of the motor power supply but
the frictional loss conflictly affects these values,
only the influence of the moment of inertia, that is,
a change in the cloth amount can be detected without
5 being disturbed by interference with the frictional
loss. Therefore, the cloth amount can be detected
even in dry condition in which high accuracy of detec-
tion is required. By supplying power under the control
of the conduction angle for the motor AC power supply,
10 the value corresponding to a minimum power level necec-
sary for starting can be determined in an easy and
simple manner.

By using the decision criterion for cloth
amount obtained through fuzzy deduction which uses in
15 the conditional part values having relation to the cloth
amount and obtained by a plurality of means, highly
accurate cloth amount decision can be effected which is
removed of the influence of disturbance factor other
than the cloth amount and which is adaptive to changes
20 in ambient conditions.

Further, by using the decision criterion for
cloth amount obtained through fuzzy deduction based on
the aforementioned two values for which the influence
of the moment of inertia and the influence of frictional
25 loss in mechanism components are cancelled out, proper
decision of cloth amount can be carried out which can
exclude the influence of frictional loss and which
can take into account changes in ambient conditions such

1 as temperature and humidity, the manner of laying cloths
and experience of the user.

5 In accordance with the aforementioned home
position stopping technique, after deactivation of the
drum, a value of the overrunning amount of the drum is
once detected. Subsequently, the drum is restarted for
rotation and a halt signal based on the previously
detected overrunning amount value is applied. As a
result, the lid of the drum can be stopped at the
10 reference position and the error in the stop position
can be controlled approximately to the resolution of the
rotational position detector.

15 Repetitive corrections after deactivation of
the drum can be dispensed with, the time lapse preceding
the home-position stoppage becomes stable and for any
frictional loss and load, oscillation will not be liable
to occur.

Further, the rotation angle is detected during
washing and drying or dehydration at low speed by using
20 the same rotational position detector as that used for
detection of stoppage of the drum and especially when
forward and reverse rotation angles of the drum to be
detected by means of an encoder (rotational position
detector) are represented in terms of random number,
25 washing power which does not depend on the load can be
obtained, making it possible to provide a full-automated
washing and drying machine which can be reduced in
washing non-uniformity, dehydration non-uniformity and

1 drying non-uniformity.

In addition, in accordance with the aforementioned technique for improving the washing and drying performance, the rotation angle is controlled 5 and hence forward/reverse rotation of the drum during washing and drying can be carried out steadily for any load amount, thus making a contribution to improvement of washing performance; and besides, the location of the washing can always be moved inside the drum, 10 providing a full-automated washing and drying machine of less washing non-uniformity and drying non-uniformity.

Preferred embodiments of the present invention will now be described by way of example, with reference to the accompanying drawings, in which:-

15 Fig. 1 is a block diagram showing the construction of a controller of a full-automated washing and drying machine according to the invention;

Fig. 2 is a schematic perspective view showing the full-automated washing and drying machine;

20 Fig. 3 is a selective, schematic longitudinally sectional view showing a section participating in drying;

Fig. 4 is a longitudinally sectional view showing the overall construction of the full-automated washing and drying machine;

25 Fig. 5 is a sectional view taken on the line X-X of Fig. 4;

Fig. 6 is a sectional view taken on the line Y-Y of Fig. 4;

Fig. 7 is an enlarged front view, partly

1 exploded, showing a rotational position detector shown
in Fig.1;

Fig. 8 is an enlarged fragmentary sectional
view of the Fig. 7 rotational position detector;

5 Fig. 9 is a diagram illustrating patterns
on a reflection plate 2;

Fig. 10 is a problem analysis diagram (PAD)
showing an example of operation where decision of the
cloth amount is carried out through two steps;

10 Fig. 11 is a PAD showing another example of
operation where the cloth amount decision is carried
out through three steps;

Fig. 12 is a PAD showing the outline of a
cloth amount detection system;

15 Fig. 13 is a PAD showing the operation of an
encoder serving as the rotational position detector;

Fig. 14 is a schematic PAD showing the manner
of determining a value corresponding to a conduction
angle for starting;

20 Fig. 15 is a schematic PAD showing the manner
of determining an overrunning amount upon deactivation;

Figs. 16A to 16C are diagrams showing member-
ship functions of the value corresponding to the
conduction angle for starting, the value of overrunning
25 amount and the decision criterion for cloth amount,
respectively;

Figs. 17A to 17C are waveform diagrams useful
to explain conduction angle control;

1 Fig. 18 is a schematic PAD showing the manner
of stopping the drum at a home position;

5 Figs. 19A and 19B are schematic PAD's showing
modifying methods for improving accuracy of stop posi-
tion; and

5 Figs. 20A to 20D are schematic diagrams
showing the manner of operating the drum.

10 In the accompanying
drawings, Fig. 1 is a block diagram showing the construc-
tion of a controller, Fig. 2 is a perspective view
schematically showing a full-automated washing and
drying machine according to the invention, Fig. 3 is a
selective schematic diagram showing a section principally
participating in drying, Fig. 4 is a longitudinally
15 sectional view showing the overall construction of the
full-automated washing and drying machine according to
the invention, Fig. 5 is a sectional view taken along
the line X-X of Fig. 4 and Fig. 6 is a sectional view
taken along the line Y-Y of Fig. 4.

20 In these Figures, an outer frame 21 serving
as a housing is supported on rubber legs 21a, a top
cover 22 is comprised of a unitary structure of a control
board for accommodating the controller and a cover and
is fixedly secured to the outer frame 21, and a lid
25 23 is hinged to the cover.

1 An outer tank 24 is constructed of a cylinder
24a and side plates 24b and 24c. The cylinder 24a
is formed at its upper peripheral portion with an
opening 24d for change/discharge of the washing, as
5 designated by A, and at its lower peripheral portion
with a drainage port 24e. A water teeming port 24f
is attached to an upper peripheral portion of the
cylinder 24a. The side plate 24b is formed, near its
center, with an opening 24g through which air is sent
10 to a drum 27 during drying. The outer tank supports,
at the centers of the side plates 24b and 24c, the
drum 27 through bearings and contains washing water.

A tank cover 25 has an opening 25a the wall
of which engages the periphery of the opening 24d in the
15 outer tank 24 to secure the tank cover 25 to the outer
tank 24, and an outer tank lid 26 is hinged to the
tank cover 25. The drum 27 has a dual function of
washing tank and dehydrating tank and at the same time
serves as a drying container. The drum 27 is constructed
20 of a cylinder 28 and side plates 29 and 30.

A plurality of lifters 28a are provided on
the inner periphery of the drum 27 at equal intervals
and they extend radially, in order that washing opera-
tion can be carried out while exerting an impact to
25 the washing A during washing and drying operation can
be carried out while stirring the washing A during
drying. Small perforations 28b of a diameter of 4 to
6 mm act as dehydration holes during dehydrating operation

1 and also act as exhaust holes for wet air during drying
operation.

These small perforations 28b are formed
over the entire periphery of the drum 27 such that they
5 are thin on the hot-air blowing side and dense on the
opposite side. The drum 27 is partly cut and opened to
form a charge port 28c for charge/discharge of the
washing A, and a drum lid 31 is hinged to the peripheral
edge of the charge port 28c.

10 The side plate of drum 27, which is on the hot-
air blowing side during drying, has its central portion
formed into a recess 29a the outer periphery of which
is of an annular plane and formed with a number of
small perforations for hot-air blowing. The side plate
15 30 is arranged opposite the side plate 29, having the
same shape as that of the side plate 29, and formed
with a recess 30a and small perforations 30b for wet air
exhaust.

A rotary shaft 32 is comprised of a unitary
20 structure of a hub 32a secured to the side plate 29
of the drum 27 and a shaft 32b, and a rotary shaft
33 is comprised of a unitary structure of a hub 33a
secured to the side plate 30 and a shaft 33b fixedly
mounted with a pulley 34. The pulley 34 is adapted
25 to drive the drum fixed to the shaft 33b.

A four-pole capacitor induction motor 35 is
adapted to drive the drum 27 and it is fixedly mounted
to the bottom of the outer tank 24. During washing

1 and drying, the motor 35 is driven to rotate the drum
27 forwardly and reversely through a speed reduction
unit 36. During dehydration, the motor is first
rotated at a low speed and thereafter it is not subjected
5 to speed reduction but is rotated at a high speed.

Like the motor 35, the speed reduction unit
36 is fixedly mounted to the bottom of the outer tank
24 and it is operated under the control of a micro-
computer 71 through a clutch motor 84 as shown in Fig. 1
10 to effect switching between high speed and low speed,
as will be described later.

A pulley 39 is fixed to a shaft 35a of the
motor 35, a pulley 40 is fixed to an input shaft of
the speed reduction unit 36, and a belt 41 is applied
15 over the pulleys 39 and 40. A pulley 42 is fixed to
an output shaft 36a of the speed reduction unit 36,
and a belt 43 is applied over the pulley 42 and drum
drive pulley 34.

In a through-flow type circulation fan 44, a
20 casing 44b is divided into right and left two portions
at the boundary including the center of an impeller
44a, and a suction port 44c is provided on the side of
one portion and a release port 44d is provided on the
side of the other portion. The fan is fixed to an upper
25 portion of the side plate 24b of the outer tank 24 and
during drying, it is operated to supply hot air to the
drum 27 and circulate exhausted wet air, as indicated
by arrows in Fig. 3.

1 A fan shaft 45 is supported on bearings at
the front and back side plates of the casing 44b and
a pulley 46 is fixed to the fan shaft 45. A heating
chamber 47 is arranged internally of the center portion
5 of the side plate 24b of outer tank 24 and fixed to
the side plate 24b so as to be airtightly, snugly
fitted in the recess 29a in the side plate 29 of drum
27. The lower half of the heating chamber has an
opening 47a through which hot air is injected into the
10 drum 27. An annular air-tightness maintaining member
48 is interposed between the recess 29a of the side plate
29 of drum 27 and the heating chamber 47. A sheathing
heater 49 for heating wet air to be circulated and
supplied to the drum 27 during drying is accommodated
15 in the heating chamber 47.

 A drainage chamber 50 is connected to the
drainage port 24e of the outer tank 24 and it has a
drainage hole 50a in communication with a drainage valve
55, a hole in communication with a trap 53 and a con-
20 nection to a duct 51. The duct 51 extends upright
from the drainage chamber 50 and connects to the suction
port 44c of the circulation fan 44, having a midway
sprinkler port 52 connected to a water feed valve (C)
61 and being operable to sprinkle cooling water down-
25 wards. The drainage valve 55 is in communication with
the drainage hole 50a and a drainage hose pipe 56 is
connected to a release tube of the drainage valve 55.

 A fan motor 57 for driving the circulation

1 fan 44 is fixed to the bottom of the outer tank 24, a
pulley 58 is fixed to the shaft of the fan motor 57 and
a belt 59 is applied over the pulleys 58 and 46. Water
feed valves (S) 60 and (C) 61 are integral with each
5 other, having a common inflow port for water supply
and individual independent release tubes.

The water feed valve (S) 60 is opened during
washing and rinsing to feed water into the outer tank
24 and the water feed valve (C) 61 is opened during
10 drying to sprinkle cooling water into the duct 51.
A flow rate limiter 62 is connected to the release port
of the water feed valve (C) 61 and is operable to
automatically change its flow path area in accordance
with the magnitude of water pressure of water supply
15 in order to feed into the duct 51 cooling water which
is always at a constant flow rate. A water absorber
63 is formed of water absorbent, longitudinally elongated
plate materials which are accommodated in the duct 51
so as to be juxtaposed, leaving behind gaps therebetween.
20 Reference numeral 64 designates a water feed hose pipe,
65 a water teeming hose pipe for connecting the release
port of the water feed valve (S) 60 and the water teeming
port 24f of the outer tank 24, and 66 a tube of small
diameter.

25 Shock absorbers 67 are each comprised of a
rod 67a and a buffer 67b incorporating a compression
coil spring and they are hung on four corners of the
outer frame 21 to buffer support the outer tank 24.

1 Referring now to Figs. 7 to 9, the construction
of a rotational position detector for detecting the
rotational position of the drum will be described.

5 Fig. 7 is a partly exploded front views
showing the construction of the rotational position
detector mounted near the rotary shaft 33 of the drum
27, and Fig. 8 is a sectional view of Fig. 7.

10 Illustrated in these Figures are the rotary
shaft 33 of the drum 27, the pulley 34, the belt 43 for
transmitting torque of the motor 35 to the rotary shaft
33 of the drum 27, an interrupter holder 3 mounted to
the side plate 24c, reflection type photo-interrupters
15 4, 5 and 6 carried on the interrupter holder 3 (each
interrupter being an optical coupling device which is
comprised of a light emitting element and a light
receiving element and in which the light receiving
element receives light, emitted from the light emitting
element and returning in the form of reflection light,
to produce an output), and a reflection plate 2.

20 Fig. 9 is a front view of the reflection
plate 2 shown in Fig. 8. Referring to Fig. 9, a pattern
7 is located at the outermost circle, a pattern 9 is
located at the inner circle and a pattern 8 is located
at the intermediate circle. Denoted by 10 is a hole
25 through which the rotary shaft 33 is inserted.

The reflection plate 2 is fixed to the pulley
34 and rotated along with the drum 27. The reflection
plate 2 has the patterns 7, 8 and 9 as shown in Fig. 9

1 which are set up by using black portions of low optical
2 reflection factor and white portions of high optical
3 reflection factor. The interrupter holder 3 opposes
4 the patterns on the reflection plate 2 and immovably
5 secured to the side plate 24c of the outer tank 24.
6 The reflection type photo-interrupters 4, 5 and 6 on
7 the interrupter holder 3 have a focal distance of 4 mm.
8 The reflection type photo-interrupter 6 opposes the
9 pattern 7; and similarly, the interrupter 5 opposes
10 the pattern 8 and the interrupter 4 opposes the pattern
11 9. Signals of "0" or "1" corresponding to black portion
12 or white portion of the pattern 9 can be obtained from
13 each photo-interrupter. Since in this example, the
14 patterns 8 and 9 are dephased from each other, the
15 reflection type photo-interrupters 5 and 4 generate a
16 two-phase signal of 90-degree phase difference as the
17 drum 27 rotates.

18 The direction of rotation of the drum 27 is
19 determined by using the two-phase signal and for
20 example, when the drum 27 rotates to the right, that
21 is, clockwise, output signals of the photo-interrupters
22 are counted up by means of a counter (the microcomputer
23 71 in Fig. 1) and when the rotation is to the left,
24 the output signals are counted down, thereby making it
25 possible to know a rotational position of the drum 27.

26 The pattern 7 is positioned to oppose the
27 reflection type interrupter 6 when the drum lid 31 is
28 aligned with the opening 24d of the outer tank 24, so that

1 a reference position signal may be delivered.

The controller cooperating with the above construction will now be described with reference to Fig. 1.

5 The microcomputer 71 is the heart of control and receives the two-phase signal and reference position signal from the rotational position detector, as designated by reference numeral 1, and input signals from a cloth amount detection unit 87, a deflection 10 sensor 74 not shown in Figs. 2 to 6 which is adapted to detect vibrations of outer tank 24 caused during dehydration, a water level sensor 75 not illustrated in Figs. 2 to 6 which is adapted to detect the water level of washing water supplied from a bibcock to the 15 outer tank 24 through the water feed hose pipe 64 and water teeming hose pipe 65 and filled in the outer tank, operation/input means 73 and a zero-cross circuit 76 adapted to detect timings at which voltage of an AC power supply 88 assumes zero.

20 The microcomputer 71 is associated with output units including a display unit 72 for displaying decision results of the cloth amount in the form of, for example, documents, sound or voice and an instruction for expediting the next operation, the motor 35, 25 the clutch motor 84 for switching the speed reduction unit 36, the fan motor 57, a drainage motor 85 for open/close of the drainage valve 55, the sheathing heater 49 and a water feed solenoid 86 for open/close of the

1 water feed valve 60. Excepting the display unit, the
output units are connected to the microcomputer 71
through AC switches 77, 78, 79, 80, 81, 82 and 83
which are constructed of, for example, SSR's (solid-
5 state relays).

Referring now to Figs. 10 and 11 and PAD's
(problem analysis diagrams) of Figs. 12 to 15, the
manners of selecting operations and detecting the cloth
amount in the full-automated washing and drying machine
10 according to the invention will be described.

Fig. 10 shows an example of operation where
decision of the cloth amount is carried out through
two steps and Fig. 11 shows another example where the
cloth amount decision is effected through three steps.

15 As is clear from Figs. 10 and 11, in the
full-automated washing and drying machine of the
invention, when the power supply is turned on and cloths
standing for the washing are charged into the drum 27,
the cloth amount detection is first carried out in
20 advance of water teeming.

The cloth amount detection unit 87 may be
based on a variety of methods such as a method to be
described later for determining inertia of cloths, a
method described in, for example, Japanese Patent
25 Application Laid-open Hei 2-241493, page 11 wherein the
weight of cloths is detected by measuring strain in
the shock absorbers 67 (or called suspensions) adapted
to buffer support the outer tank 24 by means of a strain

1 gauge, a method as described in Japanese Patent Application Sho 63-283174 which utilizes electromotive force reflecting weight applied to a piezoelectric sensor carried on the shock absorber 67, and a method 5 as described in Japanese Patent Application Laid-open Sho 57-115286 which detects the height of washing cloths by means of an ultrasonic sensor.

When the cloth amount detection is completed, it is decided by decision means comprised of the micro-computer 71 on the basis of information indicative 10 of cloth amount detection results whether drying is permitted for execution or not.

When drying is decided to be permissible in the case of Fig. 10, a document stating, for example, 15 "Does the operation extend to drying?" is first displayed on the display unit 72. If an operation key (not shown) of operation/input means 73 corresponding to, for example, "Y (or 1)" is depressed, a drying course covering washing, rinsing, dehydration and 20 drying is set by means of automatic setting means comprised of the microcomputer 71 and operation is started. If "N (or 2)" is depressed, a washing course beginning with washing and subsequent rinsing and ending in dehydration is similarly set and operation 25 is started.

On the other hand, when drying is decided to be impermissible, documents, for example, "1: Is the amount of cloths decreased?", "2: Does the operation

1 end in dehydration?" and "3: Are the cloths as they are
dried?" are displayed on the display unit 72 to expedite
the next operation. If the user depresses an operation
key (not shown) corresponding to "document 1", "Decrease
5 the amount of cloths. Are you ready?" is displayed
on the display unit 72. Then, when the user decreases
the amount of cloths and depresses, for example, the
operation key (not shown) of operation/input means 73
corresponding to "Y (or 1)", the aforementioned drying
10 course is similarly set and operation is started. If
an operation key (not shown) corresponding to "document
2" is depressed, a document, for example. "The opera-
tion begins with washing and ends in dehydration"
indicative of the results of setting is displayed on
15 the display unit 72, the washing course is set by means
of the automatic setting means and operation is started.
If an operation key (not shown) corresponding to
"document 3" is depressed, a document, for example,
"The cloths as they are dried" indicative of the results
20 of setting is displayed, the drying course is set by
means of a first automatic setting means comprised of
the microcomputer 71 even when the cloth amount is
large, and operation is started.

In Fig. 11, decision means performs three-
25 step discrimination inclusive of fuzziness which is
represented by a first state of "The operation is
permitted to extend to drying", a second state of "The
cloth amount is slightly excessive for drying" and a

1 third state of "The cloth amount is too large to effect
drying". Accordingly, when the first state is determined,
display and setting are carried out in a similar manner
to the case where drying is decided to be permissible
5 in Fig. 10. When the second state is determined,
display and setting are executed in a similar manner to
the case where drying is decided to be impermissible
in Fig. 10. When the third state is determined, a
document, for example, "Is the cloth amount decreased?"
10 is displayed on the display unit 72. Then if, for
example, the operation key (not shown) of operation/input
means 73 corresponding to "Y (or 1)" is depressed,
"Decrease the cloth amount" is displayed to expedite
the next operation. The operation then returns to the
15 cloth amount detection, thereby ensuring that it is
possible for the operation to extend to drying. If
"N (or 2)" is depressed, the washing course beginning
with washing and subsequent rinsing and ending in
dehydration is similarly set by means of a second
20 automatic setting means comprised of the microcomputer
71, a document, for example, "The operation begins with
washing and ends in dehydration" indicative of the
results of setting is displayed on the display unit
72, and operation is started.

25 The operational principle of the cloth amount
detection unit 87 according to the invention which is
based on the method for determining inertia of cloths
and which does not require any separate sensor will

1 now be described. The principle will first be outlined
and then detailed. Fig. 12 shows a schematic PAD of
the entirety of the present detection system and the
following description will be given in accordance with
5 Fig. 12.

In the present cloth amount detection system,
a quantity corresponding to minimum electric power
necessary for starting the container (drum 27) charged
with cloths by means of the motor 35 is first detected
10 as an angle of electric conduction applied from the AC
power supply to the motor 35 by using the rotational
position detector 1. This detection is repeated a
few times to improve accuracies. Subsequently, an
amount of an overrunning rotation beginning with turn-
15 off of the power supply for the motor 35 and ending
in stoppage of the drum 27 following its rotation due
to inertia is detected using the rotational position
detector 1. Similarly, this detection also repeats
itself a few times to obtain a mean value used as a
20 detection value.

Values of the two types of detections are
used by the microcomputer 71 to determine the amount
of cloths in the drum 27 through, for example, fuzzy
deduction process.

25 The manner of detecting the quantity corre-
sponding to power necessary for starting as the angle
of electric conduction applied from the AC power supply
will be described in greater detail with reference

1 to Fig. 14.

An AC voltage waveform supplied from AC power supply 88 to motor 35 is illustrated in Figs. 17A, 17B and 17C. In the voltage waveform, the timing at which 5 voltage of the AC power supply assumes zero is detected by the zero-cross circuit 76 and a detection signal is applied to the microcomputer 71. Subsequently, lagging time DT following the zero-cross point is set. Then, a trigger pulse of about 2 to 3 ms is applied 10 from microcomputer 71 to solid-state relay 77 to turn it on. As a result, power corresponding to a hatched area in the half cycle is supplied to the motor 35. Thus, a conduction angle applied to the motor 35 is defined by a phase angle which corresponds to an interval 15 of time between the termination of lagging time DT and the succeeding zero-cross point. (Practically, it is preferable that the operation be started at a conduction angle of about 30 degrees.)

On the other hand, during the above procedure, 20 the rotational position detector 1 continues supplying the aforementioned two-phase signal to the microcomputer 71.

The above operation repeats itself by about 2 to 6 cycles while confirming by using the rotational 25 position detector that during this phase of operation, the motor 35 is not started yet and consequently the drum 27 does not start rotating.

Thereafter, the lagging time DT is decreased

1 by δT which is about 0.25 ms and under this condition,
the operation similarly repeats itself by 2 to 6 cycles.
In other words, the conduction angle is increased
slightly to increase power supplied to the motor 35.
5 During this procedure, the rotational position detector
1 fetches data of two-phase signal as shown in a PAD
of Fig. 13. As the drum 27 starts rotating, the data
changes to reach a predetermined count value, for
example, 4 which defines starting of the drum. A value
10 corresponding to a conduction angle at that time is
defined as a value representative of power required
for starting the motor 35. This value is indicated by
(FKDAT1).

15 The manner of detecting the overrunning rotation amount will now be detailed with reference to
Fig. 15.

20 Firstly, after cloths are charged into the drum 27, the motor 35 is driven, for example, clockwise to rotate the drum clockwise by one or more revolution. As the rotary shaft 33 rotates along with the drum 27, the timing comes at which the pattern 7 on the reflection plate 2 opposes the photo-interrupter 6 to cause it to deliver the reference position signal. At that timing, the reference position signal, as designated by Z, changes its value from 1 (high) to 0 (low) because the pattern 7 is a black portion of low optical reflection factor.

25 At the timing that the value of the reference

- 1 position signal changes from 1 to 0, the motor 35 is deactivated (or electromagnetic braking is applied). Concurrently therewith, the microcomputer 71 resets the count value (encnt) obtained from the rotational
- 5 position detector 1 to zero and restarts the counting.

Since the motor 35 is deactivated from the power supply, the drum 27 then continues rotating by its inertial force which depends on cloths contained in the drum 27. Throughout the continuation of this rotation, 10 the rotational position detector 1 transmits the two-phase signal to the microcomputer 71 which in turn continues counting the count value (encnt). When the drum 27 subsequently stops, the count value (encnt) is detected as an overrunning rotation amount (FKDAT2) of 15 the drum 27 following the deactivation of the motor 35 and stored in the microcomputer 71.

The previously obtained value (FKDAT1) corresponding to the conduction angle for starting and the thus obtained value of overrunning (FKDAT2) can be 20 expressed by the following equations:

$$FKDAT1 = C1 \cdot M + C2 \cdot F$$

$$FKDAT2 = C3 \cdot M - C4 \cdot F$$

where M: moment of inertia of cloths and drum 27

F: frictional loss in mechanism components

25 C1 to C4: constants determined by a washing machine used (C1, C3, C2 · F and C4 · F are determined experimentally.)

1 Accordingly, from the two values, a value X
effective to minimize the influence of frictional loss
F can be obtained as a decision criterion for cloth
amount detection, as follows:

$$\begin{aligned} X &= \text{FKDAT1} + \text{FKDAT2} \\ &= (C1 + C3)M + (C2 - C4)F \end{aligned}$$

5 If FKDAT1 or FKDAT2 is multiplied by constant
C so that $C2 - C4 = 0$ may stand, then there results

$$\begin{aligned} X &= \text{FKDAT1} + C \cdot \text{FKDAT2} \\ &= CC \cdot M \end{aligned}$$

In this manner, the value X is affected by
only the moment of inertia of cloths and the drum 27.
(CC is determined experimentally.)

10 In the full-automated washing and drying machine,
the amount of cloths must be detected while the cloths
remain dried (before water is teemed). Obviously, the
moment of inertia due to the cloth amount is less affected
by dry cloths than wet cloths and therefore, under the
15 dry condition, high accuracies are required for detecting
a cloth amount from a change in moment of inertia.
Further, in detecting weight of cloths, a strain gauge
is used to measure a maximum value of cloth amount of
5 kg with a requisite value of resolution of 1 kg or less
20 and also a total weight of 30 to 40 kg of drum 27, outer

1 tank 24 and motor 35 which are suspended from the shock
absorbers 67. Therefore, highly accurate resolution
is also required within the range of measurement of
the strain gauge. This holds true for emasurement based
5 on pressure. In detecting the height of cloths of
the washing by means of an ultrasonic sensor, the top
surface of the washing becomes disadvantageously unsettled
depending on the manner of laying the washing. Under
the circumstances, it is recommended that a plurality
10 of values which are substantially proportional to the
cloth amount, that is, such values as detected by the
above means be selected and a decision criterion for
cloth amount be determined through fuzzy deduction by
using the selected values in the conditional part.

15 Likewise, the detection of values corresponding
to the conduction angle for starting and the overrunning
amount is liable to be incomplete depending on conditions
of temperature, humidity and the manner of laying cloths.
But since the terms representing frictional loss can
20 be cancelled out, highly accurate measurement can be
expected. Thus, fuzzy deduction based on the two types
of values of conduction angle and overrunning amount
to determine a decision criterion for cloth amount may
be employed as will be exemplified below.

25 The conditional part of deduction uses the
value corresponding to a conduction angle for starting
(FKDAT1) and the value of an overrunning amount (FKDAT2)
to deduce a cloth amount in the conclusion part.

1 For example, membership functions as shown
in Figs. 16A and 16B are defined for values corresponding
to conduction angles for starting (FKDAT1) and values
of overrunning amount (FKDAT2), and function values are
5 determined by looking up the membership functions. When
the membership functions are defined as illustrated by
sorting the values corresponding to conduction angles
for starting (FKDAT1) into three fuzzy levels of (large,
medium, small) and the values of overrunning amount
10 (FKDAT2) into four fuzzy levels of (large, slightly
large, medium, small), $(3 \times 4) = 12$ deduction rules
in total are available.

15 In deduction operation, grades in the condi-
tional part are first determined, deduction results in
the conclusion part are then obtained in connection with
the individual rules and the decision criterion for
cloth amount is determined through centroid method.

Operation of deduction is carried out in
sequence as below.

20 (1) Grades in the conditional part are determined
from measured values FKDAT1 and FKDAT2.

(2) Deduction results are obtained to indicate
which fuzzy sets in the conclusion part belong to by
the individual fuzzy inference rules. For example,
25 a fuzzy set UL designated in the conclusion part is
multiplied by one grade wl in the conditional part to
obtain $U_1 \times w_1$.

(3) All fuzzy sets in the conditional part are

1 subjected to similar calculation and deduction results
obtained for the individual rules are synthesized.

(4) The center of gravity of a sum set thus
synthesized is determined to provide an output repre-
5 sentative of a decision criterion for cloth amount.

In an alternative, membership functions in
the conditional part may be defined by straight lines,
the value in the conclusion part may be defined by
a linear form which resembles the previously described
10 value X, and output values obtained in connection with
individual rules may be subjected to weighted average
to provide a decision criterion for cloth amount.

For the cloth amount, a criterion reading, for
example, "If the value corresponding to a conduction
15 angle for starting (FKDAT1) is small, then the cloth
amount is small even when the value of overrunning amount
(FKDAT2) is large." is stipulated in connection with
a rule and the cloth amount is decided in accordance
with the criterion.

20 Fuzzy stipulations are then applied to the
decision criterion for cloth amount so that any one
of three indications may be obtained finally which
are (1) not greater than the capacity for drying (the
operation can extend to drying), (2) the cloth amount
25 is slightly large (the amount of cloths should be
decreased if possible) and (3) the cloth amount is large
(the amount of cloths should be decreased).

The indication is displayed on the display

1 unit 72 as described previously in order for the user
to be informed of the indication. Accordingly, when
the indication is, for example, "the cloth amount is
slightly large", the user is permitted to operate the
5 machine by deciding as to whether the operation
should extend to drying with the cloth amount decreased,
whether the operation should end in dehydration through
washing and rinsing with the cloth amount remaining
unchanged or whether the operation should extend to
10 driving with the cloth amount remaining unchanged.

In particular, the machine construction can
be rationalized to improve ease of operation in that
when indication "(2) the cloth amount is slightly large
(the amount of cloths should be decreased if possible)"
15 is displayed, the user can decide as to whether the
operation should end in dehydration following washing
and rinsing or whether the operation should extend to
drying, and when "(3) the cloth amount is large (the
amount of cloths should be decreased)" is displayed,
20 the operation can automatically end in dehydration
through washing and rinsing.

In the foregoing embodiment, the overrunning
amount due to inertia of the drum 27 is detected using
the rotational position detector 1 adapted to detect
25 rotational of the rotary shaft 33 but it may also be
determined by turning off the motor 35 realized with
a capacitor-induction motor as usual and then counting
a number of pulses representative of voltage across

1 capacitor.

Control means for varying power during start-
ing has been described as being a conduction angle
control system but alternatively it may be constructed
5 of an inverter system.

Further, the rotational position detector 1
for generating the 90-degree dephased, two-phase signal
has been described as being an incremental type encoder
but it may alternatively be a 6-bit absolute type encoder
10 which meets a value of resolution of 36 possessed by
the rotational position detector 1.

In accordance with the invention, the drum
can be stopped at a home position in a manner as will
be described below.

15 The method for home-position stoppage of the
drum will be detailed with reference to a PAD of Fig. 18.

Firstly, the motor 35 is driven unconditionally
in, for example, clockwise direction as viewed from
Fig. 3 to rotate the drum 27 by revolution of one or
20 more. During the rotation, the microcomputer 71 fetches,
as data, a two-phase signal from the rotational position
detector 1. Driving of the motor 35 continues until
"0" (low level) of reference position signal (Z) is
produced. When $Z = 0$ is reached, the motor 35 is de-
25 activated (or electromagnetic braking is applied).

Concurrently therewith, a ring count value (RGCNT)
produced from the rotational position detector 1 is set
to zero.

1 After the deactivation of the motor 35, the
drum 27 continues rotating by its inertial force.
During this interval of time, the rotational position
detector 1 continues counting the two-phase signal.
5 Through processing by the microcomputer 71, the two-
phase signal is converted into the ring count value
(RGCNT) having levels of 0 to 35 of which 0 (zero) occurs
at the reference position.

10 A level of the ring count value (RGCNT)
obtained when the drum 27 stops is stored as data of
overrunning amount (FKCNT). If a value of FKCNT is
zero indicating that the drum lid 31 is aligned with
the opening 24d, the procedure ends. But if the value
of FKCNT is not zero, a level (STPCNT) of ring count
15 value (RGCNT) which is representative of a timing for
a halt signal to be applied to the motor 35 is determined
from $STPCNT = 36 - FKCNT$. For example, if the motor
35 deactivated at the reference position where the
level of ring count value is zero stops at 2 of ring
20 count value (RGCNT), that is, at data of $FKCNT = 2$,
then the timing for the application of the halt signal
(the deactivation of the motor 35) is changed to an
instant at which data of $STPCNT = 36 - 2 = 34$ is obtained,
in expectation of the succeeding stoppage at the referenc.
25 position of zero level of the ring count value.

Accordingly, the motor 35 restarted for
rotation may be deactivated when the ring count value
(RGCNT) coincides with the halt count (STPCNT).

1 The above method can ensure an error of
about ± 1 count and it is in general satisfactory.
Practically, however, the load amount changes greatly
in the case of the drum type washing and drying machine
5 and the machine is operated under various conditions.
Thus, the accuracy of stop position of the drum 27
may be improved and adapted for various conditions as
will be described below with reference to PAD's of Figs.
19A and 19B and waveforms of Figs. 17A, 17B and 17C.

10 Firstly, it is assumed that after the
stoppage of the drum 27 effected in accordance with the
aforementioned method, data of the ring count value
(RGCNT) is obtained which normally falls within the
range of ± 1 count relative to the reference position
15 of zero level of the ring count value. If the data
is coincident with the zero reference position, no
problem occurs; but if non-coincident, a direction in
which the drum 27 is to be driven is decided on the basis
of the data of the ring count value (RGCNT). The
20 conduction angle for power supplied from the AC power
supply to the motor 35 can be limited to 90 degrees by
applying the trigger pulse as shown in Fig. 17B. The
manner of applying this trigger pulse will be described
with reference to Fig. 19B showing a PAD for a subroutine
25 of trigger pulse generation.

 Firstly, the timing for voltage of the AC
power supply to assume zero is detected and lagging time
DT from that timing is set to 5 ms for 50 Hz. (For

1 simplicity of explanation, the initial conduction angle
is set to 90 degrees but practically, it may preferably
be about 30 degrees.) At that phase, the trigger pulse
is generated during an interval of time of about 2 to
5 3 ms. The above procedure is repeated through about 2
to 6 cycles. Subsequently, the lagging time DT is reduced
by δT of about 0.25 ms to assume 4.75 ms and the procedure
is repeated through 2 to 6 cycles. During these proce-
dures, the rotational position detector 1 fetches data.
10 The above operation is repeated and when the ring count
value (RGCNT) assumes zero, power conduction to the
motor 35 is stopped (or electromagnetic braking is
applied). Since the motor is started at the reduced
conduction angle, vibration can be reduced to advantage
15 and in addition, the overrunning amount occurring after
the application of the halt signal can be decreased.

In this embodiment, the overrunning amount
due to inertia of the drum 27 is detected using the
rotational position detector 1 but it may also be
20 determined by turning off the motor 35 realized with
a capacitor-induction motor as usual and then counting
a number of pulses representative of voltage across
capacitor.

Further, the rotational position detector 1
25 for generating the 90-degree dephased, two-phase signal
has been described as being an incremental type encoder
but it may alternatively be a 6-bit absolute type encoder
which meets a value of resolution of 36 possessed by

1 the rotational position detector 1.

Furthermore, in the full-automated washing machine and the full-automated washing and drying machine, the same rotational position detector 1 as that 5 used for detection of the home-position stoppage of the drum 27 may advantageously be used for detection of the forward/reverse rotation of the drum 27 when the rotation angle is not fixed but is changed in accordance with random number in the course of forward/reverse 10 rotation of the drum, thereby attaining effects that non-uniformity in washing and drying can be suppressed to realize a rational construction which is advantageous from the standpoint of cost.

On the assumption that the resolution of the 15 rotational position detector 1 is 36, because of the revolution number of the drum 27 during washing being set to about 100 rpm, the time per one division unit amounts to 17 ms/count and this value approximating 20 ms of the period of the AC power supply is suitable 20 for controlling the capacitor-induction motor; and besides because of the diameter of the drum 27 being about 420 mm, about 40 mm/count measures at the circumference of the drum lid 31 and this value is proper for accuracy of stoppage of the drum 27.

25 Referring now to Figs. 20A to 20D, the manner of operating the drum 27 will be described.

Firstly, when washing, the washing and a cleanser are charged into the drum 27 and washing water

1 is supplied to the outer tank 24 to a water level which
is at least below the horizontal axis passing through
the center axis of the drum 27 and which typically
corresponds to about 1/3 of the capacity of the drum 27.
5 Thereafter, the motor 35 is driven to start, for example,
counterclockwise rotation of the drum 27 (rotary shaft
33) as illustrated in Figs. 20A and 20B.

At the same time, the reflection plate 2 is
also rotated, so that a two-phase signal is produced
10 from the photo-interrupters 4 and 5 opposing the
patterns 9 and 8 and a rotation angle of the drum 27 is
detected. On the other hand, the washing is scooped
up while being stirred by the lifters 28 formed on the
inner periphery of the drum 27.

15 Thereafter, as shown in Fig. 20B, the activation
of motor 35 continues to forcibly rotate the drum
27 until the drum is rotated by at least 1/2 or less
of revolution, typically, 1/4 revolution. The time
for this rotation is defined as a forcible rotation
20 interval of drum running.

At the termination of the forcible rotation
interval, the motor 35 is deactivated and the drum 27
continues rotating by its inertia as shown in Fig. 20C.
The time for this rotation is defined as an inertial
25 rotation interval of drum running.

At that time, the washing is washed by utilizing
the fall relative to the water surface. At the
termination of the inertial rotation interval, the drum

1 27 starts rotating reversely or clockwise in this
explanation, beginning with the initial state as shown
in Fig. 20D. The operation during the clockwise rota-
tion resembles the previously-described operation with
5 the exception that the inertial rotation interval for
clockwise rotation as shown in Fig. 20C is set to 0.3
to 0.6 seconds which differs from that for counterclockwise
rotation amounting up to 1 to 2 seconds, in order to make
the forward/reverse rotation asymmetrical. Accordingly,
10 the inertial rotation angle of the drum 27 is smaller in
the clockwise rotation than in the counterclockwise
rotation.

Subsequently, the above forward/reverse rotation
is repeated to continue the washing operation. Accord-
15 ingly, in this example, the washing sequentially shifts
in the counterclockwise direction by a slight amount
corresponding to the asymmetry of the forward/reverse
rotation, thus reiteratively undergoing mechanical
energies for swinging, stirring and dropping the washing.
20 Further, when washing, the rotation angle of the drum 27
which proceeds during one cycle of the forcible and
inertial rotation intervals is so set as not to exceed
one revolution, in order that vibrations which would
be due to reaction force caused by running of the outer
25 tank 24 can be avoided. This can be done by the revers-
ing of rotation which takes place before the unbalanced
amount of the washing excites a vibratory system comprised
of the shock absorbers 67. Practically, the rotation

1 angle is determined experimentally depending on the
magnitude of vibration and washing power, having the
aforementioned values as optimum ones. Consequently,
displacement of the drum 27 due to vibration can be
5 minimized, making it possible to minimize the size of
the outer frame 21 to advantage.

In the precedence, the inertial rotation
interval has been described as being asymmetrical but
alternatively the forcible rotation interval may be
10 asymmetrical to proceed, for example, 1/4 revolution in
the counterclockwise direction and 1/5 revolution in the
clockwise direction.

In the succeeding rinsing and drying operations,
the drum 27 is operated in a manner similar to the above.

15 With the construction described as above, the
present invention is expected to attain the following
effects.

(1) At the time that cloths are charged, the user
is informed, in advance of teeming water, of whether
20 the amount of cloths permits the operation to extend to
drying or not. If a negative indication is displayed,
then the user is permitted to determine that the cloth
amount should be decreased, with the result that such
inconvenience as generation of wrinkles at the termination
25 of drying can be prevented and ease of operation can
be improved.

(2) At the time that the washing (cloths) is
charged, the cloth amount is decided, in advance of

1 teeming water, as to whether to be permissible for
drying or not and a result of decision is displayed
and the user is informed of the result. Therefore, in
advance of teeming water, the user can select the next
5 operation in accordance with information about the
cloth amount by deciding as to whether the operation
should extend to drying, whether the cloth amount
should be decreased or whether the operation should end
in dehydration following washing without extending to
10 drying. Accordingly, such inconvenience that the
operation expected to extend to drying is forced to end
in dehydration can be prevented and ease of operation
can be improved.

(3) When the indication of the cloth amount is
15 stipulated in three steps of ① not greater than the
capacity for drying (the operation can extend to drying),
② the cloth amount is slightly large (the amount of
cloths should be decreased if possible) and ③ the
cloth amount is large (the amount of cloths should be
20 decreased), the operation meeting various conditions
of cloth quality can be carried out. For example, even
when "② the cloth amount is slightly large" is
displayed, for the washing allowed to be slightly
wrinkled, the operation can be extended to drying with
25 the cloth amount remaining unchanged.

(4) The user is permitted to determine that the
operation is allowed to extend to drying when indication
"② the cloth amount is slightly large (the amount of

1 cloths should be decreased if possible)" is displayed,
but the operation automatically ends in dehydration
through washing when indication "(3) the cloth amount is
large (the amount of cloths should be decreased)" is
5 displayed, thus making it possible to provide a rational,
full-automated washing and drying machine.

(5) When the decision criterion for cloth amount
is determined on the basis of values corresponding to
the overrunning amount and the conduction angle for
10 starting in accordance with teachings of the invention,
changes in ambient temperature and changes in rotational,
frictional loss in the drum due to changes in tension
in the V belt connecting the motor and the rotary shaft
of drum can be neglected and steadiness of cloth amount
15 detection can be ensured.

(6) When the decision criterion for cloth amount
is determined through fuzzy deduction using, as values
related to cloth amounts obtained from a plurality of
means, values corresponding to the overrunning amount
20 and the conduction angle for starting, the thus
determined decision criterion for cloth amount can
take advantage of empirical knowledge of various condi-
tions of temperature, humidity and the manner of
laying cloths.

25 The invention can attain further effects as
below.

(7) Since the overrunning amount is once detected
following deactivation of the drum 27, the drum 27 can

1 assume the home position regardless of inertial force
due to load amounts and frictional loss in shafts.

(8) When the overrunning amount after deactivation
of the drum 27 is determined by counting a number of
5 pulses across capacitor of a capacitor-induction motor,
the conventional cloth amount detector circuit can be
used as it is to advantage from the stand-point of
cost.

(9) When the rotational position detector 1 is
10 realized with an incremental type encoder, the number of
signal lines can be minimized to provide high resolution.

(10) When an absolute type encoder is used as the
rotational position detector 1, the number of signal lines
are increased but the encoder does not cause shifting
15 of data even when the power supply is turned off in
the course of stop operation of the drum 27, thus
simplifying the processing by the microcomputer.

(11) When the encoder is constructed of the reflec-
tion plate 2 carried on the pulley 34 and the reflection
20 type interrupters 4, 5 and 6 fixed to the outer tank 24,
the wiring processing can be simplified and appropriate
resolution can be obtained.

(12) By controlling the rotation angle during washing,
drying and dehydration by means of the same rotational
25 position detector as that used for stopping the drum 27
at the home position, rotation angle control not depending
on the load amount can be ensured to advantage from the
standpoint of cost.

1 (13) Random number values are applied to values of the forward/reverse rotation angle of the drum 27 to contribute to reduction of non-uniformity in washing and drying.

5 (14) With a value of resolution of the rotational position detector 1 set to about 36, time per one division unit substantially equals the period of the AC power supply and this value is proper for accuracy of stoppage of the drum 27.

10 (15) By deciding the drive direction of the motor 35 after the drum 27 is stopped at the home position in accordance with the above method, driving the motor at the conduction angle which varies from a small value to a large value in a so-called soft start fashion and 15 stopping power conduction when the reference position is reached, accuracy of stop position of the drum 27 can be improved.

Further, the invention can attain the following effects.

20 (16) For removal of dirts, it is indispensable to provide the action for weakening force interacting fibers of cleanser and particles of dirts and the mechanical energies for separating dirts from fibers. In accordance with the invention, the rotation angle can 25 be detected even when the amount of the washing is excessive and the mechanical energies can be applied uniformly to the washing, thus making a contribution to promotion of washing power.

- 1 (17) Non-uniformity in washing can be minimized.
- (18) When drying, similar operations can be carried out to decrease non-uniformity in drying.
- (19) Further, vibrations occurring especially
- 5 during washing can be suppressed, making a contribution to size reduction of the washing and drying machine.

CLAIMS:

1. A full-automated washing and drying machine comprising:

 a controller having a container into which cloths are charged and operable to perform washing by teeming water to the cloths charged into said container, then rinsing, dehydration and drying;

 cloth amount detection means for detecting an amount of the cloths charged into said container, in advance of teeming water;

 decision means for deciding in advance of teeming water whether the detected cloth amount is permissible for drying and so falls within such a limit value that the cloths can reach dried finish when the operation completes drying through washing and dehydration;

 display means for displaying in advance of teeming water a decision result by said decision means;

 operation/input means to be operated by the user who decides as to whether the operation should extend to drying or whether the operation should end in drying through washing and rinsing, so as to select the next operation in advance of teeming water; and

 automatic setting means for automatically setting washing, rinsing, dehydration and drying processes in accordance with the operation of said operation/input means.

2. A full-automated washing and drying machine according to Claim 1 wherein said decision means includes means capable of discriminating and determining,

a first state that the detected cloth amount falls within the drying permissible limit value and is permissible for drying,

a second state that the detected cloth amount is near the limit value and for the purpose of sufficient drying, the cloth amount should be decreased if possible, and

a third state that the detected cloth amount exceeds the limit value and for the purpose of drying, the cloth amount should be decreased.

3. A full-automated washing and drying machine according to Claim 2 wherein said automatic setting means includes any one or both of

first automatic setting means operated by the machine user to automatically set the machine operation such that the drying process following washing and dehydration is executed without the cloth amount decreased even when said decision means determines the second state that the detected cloth amount is near the drying permissible limit value and for the purpose of sufficient drying, the cloth amount should be decreased if possible, and

second automatic setting means operated by the user to automatically set the machine operation such that the drying process following washing and dehydration

is not executed when said decision means determines the third state that the detected cloth amount exceeds the drying permissible limit value and for the purpose of drying, the cloth amount should be decreased.

4. A full-automated washing machine or a full-automated washing and drying machine comprising:

a container into which cloths are charged;

a motor for driving rotation of said container charged with the cloths;

a rotational position detector for detecting the rotational position of said container;

power corresponding quantity detection means for detecting a quantity corresponding to a minimum power level necessary for said motor to start said container charged with the cloths by using said rotational position detector;

rotation overrunning amount detection means for detecting a rotation overrunning amount by which said container continues rotating following turn-off of the power supply for said motor until it stops; and

cloth amount detection means for detecting the amount of the cloths in said container on the basis of the detected rotation overrunning amount and power corresponding quantity.

5. A full-automated washing machine or a full-automated washing and drying machine according to Claim 4 wherein said power corresponding quantity detection means includes:

an AC switch connected to a feed circuit adapted to supply AC power to said motor; and means for detecting as the power corresponding quantity a value of the conduction angle for said AC switch which is gradually increased and detected when said rotational position detector detects starting of said motor.

6. A full-automated washing machine or a full-automated washing and drying machine comprising:
a container into which cloths are charged;
a mechanism including a motor for driving rotation of said container charged with the cloths;
a plurality of means for detecting a plurality of values substantially proportional to an amount of the cloths in said container; and
fuzzy logic unit for deducting the amount of the cloths in said container based on the plurality of values in the conditional part and the cloth amount by fuzzy inference rules.

7. A full-automated washing machine or a full-automated washing and drying machine according to Claim 6 wherein said plurality of means includes:

first means for detecting a first value which is substantially proportional to moment of inertia of the cloths in said container and frictional loss in components of said mechanism; and

second means for detecting a second value which is substantially in direct proportion to the moment

of inertia of the cloths in said container but is substantially in inverse proportion to the frictional loss in the components of said mechanism.

8. A full-automated washing machine or a full-automated washing and drying machine according to Claim 7 wherein said first means includes power corresponding quantity detection means for detecting as a first value a quantity corresponding to a minimum power level necessary for said motor to start said container, and said second means includes rotation overrunning amount detection means for detecting as a second value a rotation overrunning amount by which said container continues rotating following turn-off of the power supply for said motor until it stops.

9. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum, said unit comprising:

 a drum;
 a motor for driving rotation of at least said drum;

 a rotational position detector operable to generate, after deactivation of at least said drum, an output signal corresponding to a rotation overrunning amount beyond a rotation reference position for deactivation of said drum; and

 control means, responsive to the output signal of said rotational position detector, to control at least the rotation stop position of said drum.

10. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum according to Claim 9 wherein said control means controls the halt signal supplied to said drive motor on the basis of the output signal of said rotational position detector such that the halt signal is modified relative to the reference position of said drum.
11. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum according to Claim 9 or 10 wherein said rotational position detector detects the overrunning amount beyond the reference position for deactivation of said drum by detecting the rotation overrunning amount of said drive motor.
12. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum according to Claim 9, 10 or 11 wherein said rotational position detector includes an incremental type encoder operable to generate a 90-degree dephased two-phase signal as said drum rotates.
13. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum according to Claim 8, 9 or 10 wherein said rotational position detector includes an absolute type encoder operable to generate a varying signal of a plurality of bits as said drum rotates.
14. A full-automated washing machine or a full-

automated washing and drying machine having a home position stop unit for drum according to Claim 12 or 13 wherein said encoder includes a reflection plate carried on a pulley and reflection type photo-interrupters fixed to an outer tank.

15. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum according to Claim 9, 10, 11, 12, 13 or 14 wherein said control means controls the halt signal supplied to said drive motor such that the rotation angle of said drum having values represented in terms of random number is controlled in forward and reverse directions.

16. A full-automated washing machine or a full-automated washing and drying machine according to Claim 9 wherein said drum serves as a washing tank, a dehydration tank or a drying container and is supported horizontally by bearings inside a buffer supported outer tank and said rotational position detector includes an incremental type encoder for detecting the rotational position of said drum, said encoder being operable to detect the rotation angle of said drum when carrying out washing, drying or dehydration at low speed and after deactivation, detect the rotation overrunning amount of said drum beyond the reference position.

17. A full-automated washing machine or a full-automated washing and drying machine according to Claim 9 or 16 wherein resolution of said encoder is

represented in terms of the rotation angle of said drum and is about 10 degrees (one of 36 divisions of revolution).

18. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum according to Claim 9, 10, 11, 12, 13, 14 or 15 wherein said control means includes decision means for deciding the drive direction of said drive motor on the basis of the output signal of said rotational position detector, and conduction angle control means for controlling the conduction angle of drive current of said drive motor, whereby when the conduction angle of drive current of said drive motor is gradually increased from a small value until the position of said drum reaches the reference position, electric conduction to said drive motor is so controlled as to be stopped.

19. A drum type full-automated washing machine or a drum type full-automated washing and drying machine having a drum serving as a washing tank, a dehydration tank or a drying container and supported horizontally by bearings inside a buffer-supported outer tank, said machine being operable to perform the operation which can extend to drying through washing and dehydration and comprising:

 a motor for driving said drum;
 lifters radially projecting from the inner peripheral surface of said drum; and
 a rotational position detector operable to

generate an output signal corresponding to a rotation angle of said drum,

said drum being rotated alternately in forward and reverse directions during the sum of an interval of time for forcible rotation while detecting the rotation angle and an interval of time for inertial rotation which ends at the inversion of rotation.

20. A drum type full-automated washing machine or a drum type full-automated washing and drying machine according to Claim 19 wherein said inertial rotation time interval has different values for forward and reverse rotations of said drum.

21. A drum type full-automated washing machine or a drum type full-automated washing and drying machine according to Claim 19 or 20 wherein said forcible rotation time interval is asymmetrical for forward and reverse rotations of said drum.

22. A drum type full-automated washing machine or a drum type full-automated washing and drying machine according to Claim 19, 20 or 21 wherein said forcible rotation time interval represented in terms of the rotation angle of said drum is 1/4 to 1/2 revolution and one cycle of the sum of said forcible and inertial rotation time intervals does not exceed one revolution.

23. A full-automated washing machine or a full-automated washing and drying machine substantially as any of those described herein with reference to the accompanying drawings.

24. A drum-type full-automated washing machine or full-automated washing and drying machine substantially as any of those described herein with reference to the accompanying drawings.